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A
TREATISE
ON
ELECTRICITY.

By B. W. [i.e. Benjamin Wilson]

> —— Though every true ſtep made in this philoſophy brings us not immediately to the knowledge of the firſt cauſe, yet it brings us nearer to it, and on that account is to be highly valued.
>
> *Newton.*

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TO

The REVEREND

Granvill Wheeler Eſq.

Of *Otterden Place* in *Kent.*

3. 11. 08.

SIR,

OUR knowledge of natural cauſes and effects can only proceed from experiments judiciouſly made, and faithfully related. Nature is no otherwiſe known than from trials made upon herſelf, and while we advance in theſe trials, ſtep by ſtep, as ſhe leads the way, our reſearches generally prove juſt and accurate. It muſt indeed be owned, that our hopes are ſometimes diſappointed, but our very diſappointments frequently inſtruct; and by miſſing truth in one path, we often find her more eaſily in another.

THIS method of proceeding by experiment has of late years opened a large field of knowledge, and the proſpect wonderfully widens as we move forwards. Great diſcoveries have been made in this part of philoſophy;

loſophy; but perhaps as great, or greater, remain ſtill behind: and there ſeems full room left for farther inquiries.

Electricity is a part of experimental philoſophy, hitherto the leaſt inquired into; and however extenſive in itſelf (perhaps no property of matter more ſo) has been ſo little cultivated, that a ſufficient number of facts have not yet appeared, upon which its laws may be eſtabliſhed. To inveſtigate its laws, and from thence to deduce ſome certain principles of ſcience, is the intention of the following Treatiſe, which lays before you a great variety of experiments, moſt of them new, and ſome ſurprizing.

As whatever tends to promote uſeful knowledge, tends to advance the happineſs of mankind, any deſign of this nature, though imperfectly executed, cannot fail of meeting with your approbation. And beſides, there is no perſon, to whom a treatiſe on this ſubject can with more juſtice be inſcribed, than to him whoſe own reſearches, and whoſe incouragement and aſſiſtance to the late Mr. *Stephen Gray* gave riſe to thoſe extraordinary experiments, which have ſince excited the curioſity of the Public to cultivate this part of philoſophy. I am, with true reſpect and gratitude,

SIR,

Your much obliged,

and moſt obedient

humble ſervant,

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BENJAMIN WILSON.

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PREFACE.

ELECTRICAL experiments, and the cauſe of theſe wonderful effects, ſeem to have engaged, for ſome time paſt, the attention of the curious in ſeveral parts of the world, particularly in *England*.

WE are much indebted for the cultivation of this part of philoſophy to Mr. *Stephen Gray*, and Profeſſor *Muſchenbroek*: the former made the capital experiment with the glaſs tube[a], and the latter that with the vial.

CONSIDERING the great variety of experiments which have been made in this part of philoſophy, it has been very difficult to arrange them into any kind of order. And though my ſucceſs herein has fallen very ſhort of my wiſhes, yet I hope that all the defects of this work will be candidly overlooked and amended by ſome abler hand, who has more leiſure and abilities.

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[a] See the Philoſophical Tranſactions of the Royal Society, Number 417.

I HAVE, in the concluſion of this Treatiſe, delivered my opinion of ſome of the lateſt writers on this ſubject. But ſince finiſhing this book, I have met with a piece publiſhed a few months ago at *Paris*, by Monſ. *Jollabert*, profeſſor of philoſophy and mathematics, entitled, *Experiences ſur l'Electricité avec quelques conjectures ſur la cauſe de ſes effects*, by which I find he looks upon electricity and the *æther* of Sir *Iſaac Newton* to be one and the ſame[*]. That I was of opinion that the moſt ſubtile and elaſtic

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HYPOTHESE III.

[*] Je ſuppoſe d'abord un fluid très-délié, très-elaſtique, rempliſſant l'univers & les pores des corps même les plus denſes; tendant toûjours à l'équilibre, ou à remplacer les vuides occaſionnés. Je ſuppoſe encore que la denſité de ce fluide n'eſt pas la même dans tous les corps; qu'il eſt plus rare dans les corps denſes, & plus denſe dans les corps rares; enſorte que les interſtices, que laiſſent entr'elles les particules de l'air, renferment un fluide plus denſe que ne font, par example, les pores du bois ou du metal.

HYPOTHESE IV.

C'EST au moyen d'un fluide que Newton a eſſayé d'expliquer divers phénomenes, tels que ſont ceux de la lumiere & de la peſanteur. Il eſtimoit, à la vérité, que ce fluide, par lui-même & ſans avoir beſoin d'aucune preparation, produit les différentes propriétés, de la lumiere, de la gravité, &c. au lieu que, dans notre hypotheſe, il n'agit qu'après avoir été excité & mis en movement par quelque operation, telle qu'eſt le frottement &c. Cette différence dans la maniere d'agir n'empêche pas cependant que ce puiſſe être le même fluide, mais diverſement modifié, qui produit ces phenomenes differens: &, ſi nous lui donnons ici le nom *de fluide électrique*, nous ne prétendons pas pour cela borner ſes effets à ceux de l'électricité.

part of the electric matter is the ſame with the *æther* of Sir *Iſaac Newton*, appears from an eſſay publiſhed in 1746. In the beginning of the year 1747, I made ſeveral new experiments, with farther obſervations, which I ſent ſoon after to a merchant in *Holland*, who forwarded them to his correſpondent at *Paris* for Monſ. *Grand-Jean de Fouchey*, the ſecretary of the Royal Academy of Sciences. I have been informed ſince, that the ſecretary never received them. The ſubſtance of thoſe papers, together with ſome additions, make up the following Treatiſe, which is now offered to the public.

Note, The experiment in page 59, and one or two more of the following Treatiſe, were publiſhed in other words in the Philoſophical Tranſactions, Number 485. But as they were firſt made by me and Mr. *John Smeaton*, of whoſe name I have hereafter made mention, and I having occaſion to relate them, they are there inſerted. Thus much I thought proper to mention as an apology for a repetition of them.

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A TREATISE ON ELECTRICITY.

PART I.

SECTION I.

IN the making of electrical experiments the effects produced are ſo very different, according to the different methods of performing theſe experiments, that we muſt carefully attend to the moſt minute circumſtances before we can hope to arrive at any certain knowledge of the laws by which electricity acts. To obtain this knowledge, the greateſt electric effects ſeem moſt neceſſary. We ſhall therefore give an account of the ſeveral circumſtances we have always obſerved requiſite for producing them: and afterwards ſet down the ſigns by which bodies are known to be electrified; and how we are to judge of the different degrees of electrification. The machines, with which theſe kind of experiments are made, do not differ more in their conſtruction than they do in their power of electrifying. It may not be improper therefore firſt to give a deſcription of the machine with which the principal part of the following experiments was made.

A D H K repreſents a frame of wood two feet two inches long, and eighteen inches broad. The ſides of this frame are three inches by one and a half; and the diameter of the wheel F G, which alſo is of wood, fifteen inches. The axis of the wheel, E E, is ſo contrived, that it can be taken out and the wheel ſeparated from its axis, by which means they may be laid in the ſquare A M M H; it being large enough to hold not only them, but other parts of the machine. GG repreſents a glaſs cylinder with metal ends twelve inches long, and five in diameter. P, a pulley three inches diameter, fixed to one of the metal ends: round this pulley and the wheel F G is a cord or ſtring of catgut, which turns the cylinder round. The glaſs is rubbed by a cuſhion C, nine inches long and two broad, fixed to a ſpring S Y, and made to preſs more or leſs againſt the cylinder by the ſcrew y, paſſing through a croſs-bar of wood d d, fixed upon the upper-part of the frame AMMH. p, repreſents a ſmall pulley of braſs to tighten or ſlacken the ſtring, by moving it higher or lower: and it is prevented from ſlipping lower by a ſmall ſcrew h. The ſame pulley alſo ſerves to keep the ſtring from rubbing againſt itſelf when croſſed, by turning the ſtem of metal in which the pulley is fixed a little on one ſide. w w, are ſeveral ſtraight wires of *equal* lengths; one end of each is bent round, for the conveniency of hanging them on a thicker wire aaa. The wires may be raiſed or lowered by ſliding it in the hole o, let into a bar of iron BB. This bar is ſupported by ſilk lines, LLLL, tied to the four pillars of wood 1, 2, 3, 4. The whole machine is faſtened upon a table TT, by three hold-faſts with ſcrews under the angles of the frame ADK.

As to the ſeveral circumſtances that are neceſſary to be obſerved:

1. The cylinder ſhould be five inches in diameter at leaſt, and about twelve inches long.

If the cylinder be eight or nine inches in diameter, all the following experiments may be made with it; which is not the caſe with a leſs, for ſome experiments require a larger glaſs than others; as will appear hereafter.

We make uſe of a cylinder, becauſe from glaſſes of that ſhape, or oblong ſpheroids, which approach nearer to cylinders than ſpheres, we have been able to produce the greateſt effects. That cylinders or oblong ſpheroids are the moſt proper figures for this purpoſe, will be confirmed hereafter, not only from reaſon but experiments.

2. The cylinder muſt be of an equal thickneſs, or nearly ſo, if it can be had; and rather *thin* than thick, and of a good poliſh.

3. It muſt have no metal axis paſſing thro' it, unleſs the axis be covered with cement, wax, reſin, pitch, glue, or ſome other unctuous matter which is not ſoft.

4. It muſt be always freed from dirt and duſt, as well as from moiſture or dampneſs, before any experiment be made with it. To do the laſt more effectually, the looſe dirt, and that which ſometimes is found to ſtick very cloſe to the glaſs, being firſt wiped off, take a piece of clean dry flannel, and hold it near a fire till it be well warmed, then turn the wheel and rub the glaſs all over from end to end very well with it.

5. The cylinder muſt not be heated too much by continuing the friction of the cuſhion, but when an experiment has been made, let the turning of the wheel be diſcontinued for a

little time, and the glaſs be rubbed again with the dry flannel, before a freſh experiment be made.

6. The cylinder muſt be in the ſame good order for electrifying equally ſtrong, before any experiment be begun to be made with it.

To do this more effectually the following farther cautions muſt be obſerved.

7. The cuſhion C muſt be about three inches ſhorter than the cylinder is long.

8. There muſt be a piece of clean ſmooth leather (red was what I made uſe of) of a conſiderable length, and as broad as the cuſhion C is long; this leather muſt be moiſtened with a wet ſponge from time to time on the rough ſide, and afterwards, the dry ſide muſt be warmed a little by the fire; when this has been done, and the dry ſide well wiped, to free it from duſt and moiſture (there being an oily matter brought out of the leather by heating it) place it between the cuſhion and cylinder, with the dry or ſmooth ſide to the glaſs.

N. B. If the leather be gilt or covered over with ſilver, braſs, or copper, and the metal ſide applied to the glaſs (the other ſide being alſo moiſtened with water) it will do full as well.

9. The edges of this leather muſt not turn up towards the cylinder; this may be pre-

vented by rolling it up, or turning it back; or letting a ſmall weight hang to it.

10. DIFFERENT preſſures of the cuſhion againſt the cylinder will produce very different effects, therefore the preſſure ſhould be *uniform,* and rather ſtrong than otherwiſe.

11. THE wheel muſt be turned always the ſame way, ſo that the cylinder muſt turn towards the points of the wires w w, that is from C towards w w and m, and not from C towards m and ww. Thoſe points w w muſt hang cloſe to the glaſs, and about three and a half or four inches from the cuſhion.

12. THE wheel muſt be turned uniformly quick, and not faſter in one experiment than another (ſuppoſe thirty or forty turns in a minute) unleſs where it is mentioned to the contrary.

13. THE bar B B muſt be an inch and an half or two inches in diameter, and the ends rounded off hemiſpherically, unleſs we mention the contrary.

14. THE ſilk lines L L, on which it hangs, muſt be of the thickeſt ſort, and ſix inches long at leaſt, and quite dry, and free from duſt and dirt. As to the colour of the ſilk lines, let them be red or yellow.

15. METAL bodies, and ſuch as will be particularized hereafter by the name of non-electrics,

ctrics, that are to be electrified, muſt be free from duſt and dirt, and muſt have no edges, corners, or points; nor muſt wires or ſtrings be made uſe of (for they approach towards edges or points in ſome degree, by reaſon of their ſmallneſs) unleſs at any time we deſire the contrary.

16. No points, corners, or edges, or ſmall non-electric bodies muſt be any where near the body to be electrified, or the cylinder G; except thoſe points w w hanging to the ſide of the cylinder.

17. All non-electrics ſhould be above eighteen inches at leaſt, and points, corners, and edges, three feet at leaſt, diſtant from the body to be electrified, or the cylinder G: unleſs they are placed on ſuch bodies as will hereafter be diſtinguiſhed by the name of electrics: and even then points, corners, and edges of non-electric bodies muſt be avoided, except the contrary be mentioned.

18. No flame, ſmoke, or ſteams, muſt be near the machine.

19. The air muſt be dry, and freer from ſulphur than it generally is, when the days or evenings are very warm.

20. The top of the table on which the machine is fixed, as well as the machine itſelf, muſt alſo be freed from duſt.

21. The table muſt ſtand on moiſt ground, or if the table be in a chamber, a wire paſſing from the machine to the moiſt ground will do full as well.

22. When we mention *wax*, it is with indifference, for either glaſs, reſin, pitch, glue, ſilk or hair, do as well.

23. Common bees wax of itſelf is too ſoft: therefore a quantity of reſin (half as much, or more) ſhould be diſſolved in it, which will make the mixture, when cold, much harder and fitter for uſe.

24. When either wax, reſin, pitch, glue, glaſs, hair, or ſilk lines are made uſe of, we always ſuppoſe them very dry, and freed from duſt and dirt; and the five firſt to be ſix inches thick, and the two laſt to be ſix inches long at leaſt, unleſs the contrary be mentioned in any experiment.

25. When a body is to approach, or be brought near an electrified body, we always ſuppoſe theſe three things to be carefully obſerved. Firſt, that the approaching body be in contact with the earth at the ſame time. Secondly, that the approaching part be a rounded ſurface (a quarter of an inch at leaſt in extent) free from points, corners, or edges. And laſtly, that it be moved towards the electrified body, not ſlowly, but very quick: unleſs at

any time the contrary of any of theſe things be mentioned. If the electrified body be the approaching body, we ſuppoſe it to be moved towards the other alſo very quick.

26. Before a freſh experiment be made with the ſame body, we always ſuppoſe no ſigns of its being electrified remaining.

27. If a perſon ſhould rub the glaſs with his hand inſtead of the cuſhion, we ſuppoſe it to be in the ſame place where the cuſhion is placed, and with the ſame preſſure, with reſpect to the ſigns by which bodies are known to be electrified.

The cylinder G, or bar B B (or any other body) is ſaid to be electrified when light bodies of any kind are moved to and from any part of the cylinder or bar. And when two or more very light or flexible bodies of any kind, placed near one another, and in contact with any part of the cylinder or bar, are made to recede from one another by rubbing the glaſs only, the cylinder or bar is alſo electrified.

Again, the bar is likewiſe ſaid to be electrified when an exploſion and painful ſenſation happens, on a perſon's approaching any part of it with any part of his body. Or when an exploſion happens on the approach of any nonelectric body towards the bar.

THE different methods to determine the degree of electrification under certain circumſtances, as accurately as we are able, are as follow:

1. WHEN a body is electrified, obſerve the time it will take up before all ſigns of electrification ceaſe: the longer the time is, the degree of electrification will be the greater.

2. WHEN a body is electrified, obſerve the diſtance at which light bodies are moved towards it, and at what diſtance it will electrify another body, the greateſt diſtance is a ſign of the greateſt degree of electrification.

3. WHEN two light bodies are ſuſpended in threads, and electrified, obſerve how far they will recede from one another: when they recede the fartheſt, the degree of electrification is the greateſt.

4. WHEN a body is electrified, obſerve to what degree that body is capable of electrifying another body which is brought near it, both being ſuſpended in ſilk lines, or laid on wax, reſin, or glaſs: the more the firſt electrifies the other body, the degree of electrification in it will be the greater.

5. WHEN a body is electrified, and approached by another which is not electrified, to cauſe an exploſion, approach it a ſecond time, and repeat the approaches till no more ex-

exploſions enſue, obſerve their number, their degrees of *light* and *loudneſs* at each approach. The greateſt number of exploſions attended with the greateſt degrees of light and loudneſs, are ſigns of the greateſt degree of electrification.

6. WHEN a light is ſeen to iſſue from the body electrified, ſuppoſing the body ſomewhat pointed, and the room dark in which the experiment is made, and this light does not appear larger and brighter by continuing the electrification, that body is not capable of being electrified to a greater degree.

7. THE method commonly uſed to electrify bodies to the ſame degree, is to turn the wheel an equal number of times with the ſame velocity: the preſſure of the cuſhion C being always ſuppoſed the ſame, and the glaſs in the ſame good order for electrifying equally well, as we have taken notice of before.

SECTION

SECTION II.

EXPERIMENT I.

IF the cylinder of glaſs G (fig. 1.) be rubbed by the cuſhion C, the bar of iron BB with the wires ww, being ſuſpended near the glaſs on ſilk lines LL, a perſon, upon approaching the bar BB with his hand, will perceive a luminous ſpark to iſſue, accompanied with a ſnapping noiſe, and a ſmart ſenſation; and light bodies, placed at ſmall diſtances, will be moved to and from the bar.

IT appears from this experiment that friction is neceſſary to cauſe theſe phænomena; for without rubbing, the cylinder will not produce theſe effects.

THE matter cauſing ſuch effects we ſhall call *electric matter:* and the giving this property to bodies, *electrifying*.

THE luminous ſpark, whenever it is attended with a ſnapping noiſe, we ſhall call an *exploſion*.

EXPERIMENT II.

WHEN the bar BB is electrified, and a finger or piece of metal moved towards it as was done in the experiment, after an exploſion the electric matter (or the greateſt part of it) will be found to have deſerted the bar; for a ſecond effect, equal to the firſt, cannot be produced till it is again electrified. Whereas if the bar, when electrified, be approached with glaſs, amber, wax, pitch, or glue, there will be no exploſion; and the electric matter, or a conſiderable part of it, will be found to continue ſtill in the bar; for if the finger or metal be applied immediately, there will be an exploſion, and the ſame effects produced as at firſt.

EXPERIMENT III.

IF a perſon P ſtands upon glaſs, wax, reſin, or glue R, and takes hold of the bar B B, upon being electrified, he will be found to retain the electric matter in like manner as the bar. If the perſon P ſtands on any of the ſame kind of bodies as wax, reſin, glue, or glaſs, that are very thin, he will retain the electric matter in ſome degree, but not ſo ſtrongly as in the other caſe. And if the perſon P does not ſtand upon any ſuch bodies, but on the floor or earth E, and takes hold of the bar B B as before, neither he nor the bar, will appear to be electrified.

FROM the ſecond and third experiments, it appears that the electric matter does not paſs ſo readily through glaſs, amber, wax, reſin, or glue, when ſuch bodies are of a proper thickneſs, as when the ſame kind of bodies are thin: but the electric matter appears to paſs through metals and animal bodies, of all magnitudes. And ſince in the latter part of the third experiment there is not the leaſt appearance of electric matter within the perſon, or bar, and there is in the firſt part of the ſame experiment, the electric matter muſt be diffuſed and loſt in the earth.

It alſo appears that metals, when rubbed in like manner as glaſs, cannot electrify any other body: for if we ſuppoſe that the electric matter was by friction brought to, or excited in them, yet it would immediately paſs away by them.

EXPERIMENT IV.

If the wideſt end of a ſmall glaſs ſyphon be immerſed in a metalline veſſel filled with water, and ſuſpended on the bar; on turning the wheel the water will be electrified, and during the turning of the wheel, the water will in running out at the narrower end of the ſyphon ſpread to a much greater diſtance than if the water was not electrified, or the turning of the wheel was diſcontinued. And if upon ceaſing to turn the wheel, a non-electric body be brought towards the end of the ſyphon before the electric matter be intirely diſſipated, the water will again ſpread, but not to ſo great a diſtance as when the wheel is continued turning.

EXPERIMENT V.

IF a perſon ſtanding on wax, reſin, glue, or glaſs, takes hold of, and thereby becomes as it were a part of the bar or body to be electrified; or if a large quantity of iron, lead, copper, or any other metal, be ſet upon any of the above bodies, wax, reſin, glue, &c. in the place of the perſon, and communicates with the bar, upon electrification, the effects will be the ſame, whether you approach any part of that perſon, or the bar, or body electrified; that is, there will be an equal exploſion from any part of the perſon or the metal. And if the perſon electrified approaches any part of his own body, or any other body that is *equally* electrified with himſelf, there will be no exploſion.

IT appears from the fourth and fifth experiments, that when a quantity of electric matter is communicated to any of thoſe bodies (every part of which is ſuppoſed equally capable of receiving it) the ſame matter diffuſes itſelf equally throughout that body, and is conſequently *fluid*.

EXPERIMENT VI.

LET all the apparatus be placed upon cakes of wax, reſin, glue, or glaſs, ſo that all communication between the earth and the apparatus be cut off, the bar B B will not be electrified in ſo ſtrong a manner, after a few turns of the wheel, as in the other experiments.

From this experiment it appears (ſince there is no other change of circumſtances in making it, except that the communication between the machine and the earth is cut off) that the electric matter comes from the earth, and is collected, not produced by the apparatus.

That it is capable of paſſing through ſome bodies, and not through others.

The former of theſe bodies are called *non-electric*, the latter *electric* bodies.

It ſeems upon the whole of this ſection, as if the electric fluid were diffuſed throughout all bodies (at leaſt non-electrics) on, or near the ſurface of the *earth*, as well as the body of the earth itſelf.

SECTION III.

When bodies are electrified, we ſuppoſe they have received an additional quantity of electric matter, and in ſuch circumſtances the electric matter may be ſaid to be *accumulated.*

Experiment VII.

When two threads of equal lengths are hung cloſe together, and ſo as to touch the body to be electrified, they will recede further and further from each other, as the body is higher and higher electrified. And the higher the body is electrified, the longer it will be before all the electric matter be diſſipated and loſt.

If the electric matter paſſed out of the threads as faſt as it entered them, the threads could not recede from one another more or leſs, as they are more or leſs electrified; ſo that ſomething muſt in part obſtruct or hinder its paſſing out: and if the electric matter paſſes faſter in than it does out, which is here the caſe, there muſt be an accumulation; therefore the diſtance of the threads will be greater or leſs, as the accumulation of the electric matter is more or leſs increaſed: and if it be more or leſs increaſed in the threads, it muſt alſo be ſo in the bar. The truth of this is manifeſt from the effects.

EXPERIMENT VIII.

If a ſphere of iron three feet in diameter, and a ſphere of the ſame metal three inches in diameter, be placed upon ſeparate bodies of wax, and electrified at the ſame time by the bar BB, light bodies will not be moved towards the larger ſphere from a greater diſtance than towards the leſſer ſphere. But if whilſt they are electrified, both of them be immediately removed at the ſame time from the bar, the larger ſphere will retain its electric matter longer than the leſſer ſphere.

From the latter part of experiment the fifth it appears, that non-electric bodies of the ſame kind are equally electrified, when they are in contact with the electrifying body. Therefore the two ſpheres in the above experiment are equally electrified. The quantities of matter in theſe ſpheres are very different, and the times of continuing longer electrified are likewiſe different; conſequently the quantity of electric matter contained in each muſt be different. But the power of moving light bodies to and from them, is the ſame in both bodies whilſt they are in contact with the bar, or at the inſtant of removing them from the bar; and of conſequence does not depend upon the quantity of electric matter; but will be always the ſame, ſuppoſing the fluid collected equally denſe. This is the caſe with water and air (provided the denſity of the air be the ſame in different ſpaces) wherein the reſiſtance made to a body falling will be the ſame, whether the quantity of water or air be greater or leſs. But the effects of moving of light bodies, and of continuing longer electrified (as well as the magnitude of the exploſion) however, will be different, as the quantity of electric matter in any given quantity of matter differs: or, in others words, will be in proportion to the different denſity of electric matter, by experiment 7. Since then, this fluid is capable of being made more or leſs denſe, as a greater or leſs quantity may be included in the ſame ſpace, it is therefore *elaſtic:* and ſince it is elaſtic, the more it is compreſſed, with the greater force it will reſtore itſelf: and conſequently with the greater velocity.

EXPERIMENT IX.

IF two bodies x and y (fig. 4.) [a] of equal or unequal magnitudes, but equal denſities, ſuppoſe two globes of iron, the firſt electrified, the other not, are placed or ſuſpended at a given diſtance from each other upon electric bodies, or ſilk lines L L, and afterwards x be made to approach y, or y x, the quantity of electric matter will be leſſened in x, and that in a different proportion as the bulk of the body y is greater or leſs.

For if x be electrified, and of equal magnitude and denſity with y, and the former be brought near the latter, the effects of the one and the other will be found equal: if y is greater than x, their effects will be ſtill equal, but weaker, than in the other caſe: becauſe of the electric matter being expanded in a larger ſpace, or a larger quantity of matter. And therefore if y was a ſphere of one thouſand feet in diameter or more, and x one foot only, the effects would become inſenſible: even tho' the whole quantity that was accumulated in x ſhould be diffuſed in y: as may be gathered from comparing the cubes of thoſe diameters.

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[a] Mr. *Watſon* publiſhed an experiment of this kind in his *firſt Eſſay on Electricity.*

COROLLARY.

HENCE it follows, that the elaſticity of the electric fluid is leſſened in proportion as it is rarified. And hence alſo, we may eaſily conceive how the *earth* may conſtantly have this matter diffuſed *every where within it*, and yet the effect not ſenſible, till it is collected in greater quantities in any particular body.

EXPERIMENT X.

IF a long wire be extended, and ſuſpended in ſilk ſtrings, that are tied to ſtakes fixed in the ground (to prevent the wire from being near the earth or other non-electrics) and afterwards be electrified: the longer the wire is, the greater will be the effect, or painful ſenſation, upon cauſing an exploſion, by a perſon's approaching the wire.

IT has been already ſhewn (by experiment eighth) that effects apparently equal (ſuch as moving of light bodies from certain diſtances, and repelling them again) will always be produced by unequal quantities of the electric fluid, provided the denſities of the fluid be the ſame. But when the denſity of the one exceeds the denſity of the other, the difference of the effects are as that exceſs (by experiment ſeventh) the greater then the exceſs of denſity is, with the greater force, or velocity, it muſt endeavour to reſtore itſelf; conſequently the greater will be the effect or painful ſenſation.

But, *cæteris paribus*, the longeſt electrified body gives the greateſt effect, ſuch as the exploſion or painful ſenſation; therefore the electric matter muſt move with a greater velocity through a long body electrified, than through one that is ſhorter. For if the ſame wire be twiſted in a heap together very cloſe, the ſenſation and exploſion will be *much* weaker.

Experiment XI.

If the electric matter be communicated to a wire (ſuſpended as in the laſt experiment) two or three miles in length (and it is not eaſy to make the experiment with a greater length) the effect will be perceived at the further end from the machine (by moving too and fro light bodies placed near that end) as ſoon to all appearance, as at the end neareſt the machine: and if both ends of the wire be approached as near as poſſible at the ſame time, the electric matter will be only ſeen to iſſue from one of

them,

them, viz. from that which is ſooneſt approached.

Query i. Whether ſuch propagation may not be owing to the elaſticity of the electric matter? If ſo, the elaſticity thereof, in proportion to the quantity of matter it contains, muſt be vaſtly greater, than that of any other elaſtic body or fluid we are acquainted with.

SECTION IV.

PROPOSITION I.

If the ſurface of a non-electric C (pl. 1. fig. 1.) be applied to the ſurface of an electric body G, and the one be agitated by the motion of the other, a quantity of electric matter contained in one or the other, or both of them, will be excited: which quantity will be conveyed to the next adjacent non-electric body whoſe parts are not agitated, where it will be continually diſſipated; unleſs the adjacent body be ſeparated from other non-electrics by the interpoſition of electrics, in which caſe the electric matter will be retained, and accumulated therein.

The cuſhion, in this propoſition, is the non-electric repreſented by C; G is the glaſs cylinder, or the electric body; from the action of thoſe two, the electric matter is produced by their rubbing or preſſing againſt each other, the glaſs G being turned ſwiftly round: B B is the bar of iron (including the wires w w) which is the adjacent non-electric body not agitated, and L L are the ſilk lines, or the interpoſed electrics, to prevent the electric matter from diſſipating by them.

The truth of this proportion will appear from the firſt experiment, as well as from all the methods hitherto found out of accumulating the electric matter in non-electric bodies.

If the propoſition be not ſufficiently proved,

Turn the wheel the contrary way, ſo that the rubbed parts of the glaſs cylinder may paſs by the edge of the frame of the machine m, before they come to the wires w w; and the bar will appear to be electrified in a leſs degree. Lay a number of wires, ſuch as theſe marked w w (that hang againſt the cylinder) on the frame with the points or ends towards the glaſs, then continue to turn the wheel ſtill the ſame way, and the bar will appear to be electrified in a much leſs degree. But turn the wheel the other way and the bar will appear to be as ſtrongly electrified, as in experiment firſt, ſection ſecond.

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PROPOSITION II.

Supposing the bodies to be in other reſpects, as in propoſition firſt, but the adjacent non-electric one B B, which is there not agitated, to be put into an equal agitation with the other two, C and G; in that caſe, the adjacent non-electric body B B will appear to be but little, or not at all electrified.

Experiment.

Let [a] the glaſs cylinder G (fig. 1.) (which in this experiment we ſuppoſe ten inches at leaſt in diameter) be excited to electricity by means of C, or by a perſon ſtanding on the floor, applying his hand to one ſide of it; whilſt another perſon ſtanding on wax, or reſin, applies his hand in the place of the iron bar B B or the wires w w (they being taken away) and rubs that oppoſite ſide of the glaſs, in the oppoſite part g, at the ſame time, with a preſſure againſt G as nearly equal to the preſſure of C as can be judged; in ſuch circumſtances, the perſon ſtanding on the wax will be but little, if at all electrified; but let him apply his hand to the glaſs *lightly*, or the ends of his fingers only, and he will then, without any other alteration, be ſtrongly electrified.

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[a] This experiment was made by Mr. *John Smeaton*, the inventor of the new air pump.

PROPOSITION III.

WHEN a body has *loſt* any part of its original quantity of electric matter, or has *gained* an equal part, over and above what it originally had, in both theſe caſes the electric effects, ſuch as the exploſion, and the motion of light bodies towards it, will be the ſame. In the firſt caſe, theſe effects are produced by its gaining a quantity equal to that which it had loſt, and in the ſecond caſe, by its loſing a quantity equal to that which it had gained.

EXPERIMENT.

LET the perſon who turns the wheel and the machine itſelf M (fig. 2.) be placed upon electrics at ſome diſtance from all other non-electric bodies, excepting the ſuſpended bar B B, including the wires w w, which bar in this caſe muſt have a free communication with the earth, by letting ſome non-electric N touch it and the earth. Then if after a few turns of the wheel, the wheel being ſtill continued turning, another perſon approaches any part of the frame of the machine M, or the perſon who turns the wheel, an exploſion will be perceived in like manner as if the ſame were electrified; and light bodies, placed at certain diſtances from the machine or the perſon turning the wheel, will alſo be moved towards them.

Now if, in this experiment, the machine and perſon have really loſt part of their original quantity of electric matter, and any of the bodies in the firſt, third, fourth, fifth, ſeventh, eighth, ninth or tenth experiments, have really gained an equal part over and above what they originally had, then the propoſition is true. For whenever the *equilibrium* in air is deſtroyed by any part of it being rarefied or condenſed equally, that *equilibrium* will be ſoon regained. Now what is true of air, which is an elaſtic fluid, may be ſuppoſed to hold good in regard to the electric matter, which ſeems to be a fluid ſimilar to air as to its elaſticity.

PROPOSITION IV.

NON-ELECTRIC bodies, under certain circumſtances, actually loſe part of their original quantity of electric matter.

EXPERIMENT.

LET the whole apparatus be placed as in the laſt experiment, except the bar BB (fig.2.) which is now to have no communication with the earth (the non-electric N being taken away) when the bar has been electrified, and the matter diſcharged by two or three exploſions, it cannot be electrified afreſh to an equal degree, without opening a communication between the earth and the machine M, or ſetting another quantity of non-electric matter[a] which is not electrified, upon the machine M, or ceaſing to turn the wheel for a time. The machine then muſt have loſt ſome part of its original quantity of electric matter, as it no longer retains a power of electrifying the ſuſpended bar. But let the ſuſpended bar B B be held by the hands of one, two, three, or more perſons ſtanding upon wax, or let there be other large quantities of non-electric matter 1, 2, 3, and placed in the ſame circumſtances, and the machine M will appear to have loſt a yet greater quantity; which loſs will appear to increaſe as the numbers increaſe in arithmetical proportion, to a limited degree, or in other words, as the quantities of non-electric matter added are greater, to a limited degree.

ONE of theſe ſuppoſitions muſt be true, viz. that the machine is electrified in like manner as the ſuſpended bar, and receives the electric matter from without; or elſe ſuch matter is contained in the machine itſelf, and excited into action by means of friction. Now if the machine receive the electric matter from without,

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[a] The non-electric matter to be ſet upon the machine, muſt be brought to it by means of electric bodies.

out, it muſt be either from the ſurrounding atmoſphere or the earth. The firſt cannot be the caſe, for ſuppoſing it was, the effects produced would be the ſame how ever the machine was placed; upon condition only that it was placed in the open air: nor can the latter be true, ſince by ſuppoſition, in the preceding propoſition, all communication is intercepted between the earth and the machine, the electric matter then muſt be contained in the bodies themſelves. And that part of this accumulated electric matter in the bar is diſſipated upon an exploſion is manifeſt, ſince after two or three exploſions made, it is not in our power in the circumſtances deſcribed in the above experiments (how long ſoever the ſame friction be continued) to cauſe an equal number of exploſions equally ſtrong from the bar afreſh: and therefore we may conclude, that it does not iſſue from the glaſs but from the machine itſelf; for if that was ſuppoſed, an open communication between the earth and machine ought to make no difference.

When the machine and perſon turning the wheel ceaſe to electrify the ſuſpended bar of iron BB, ſome gentlemen have thought the machine itſelf and perſon turning it may be electrified, and by virtue of the whole being in a repulſive ſtate, the electric matter cannot

not paſs out of them into the bar: but this ſuppoſition does not appear to be true, as may be gathered further from the following experiments.

EXPERIMENT I.

LET two pieces of thiſtle-down be tied to ſeparate threads two or three inches long, and thoſe threads be afterwards tied to one end of a ſilk ſtring fifteen or twenty inches long, upon bringing them towards the bar, whilſt the wheel is continued turning, and the machine in contact with the earth, the fibres of the down will ſtand at a diſtance from each other, and from the bar, and be ſtretched out in many directions: whence we may ſafely conclude, that the quantity of electric matter ſurrounding any part of bodies electrified to ſome diſtances, cauſes the parts which are free and at liberty (and ſuch are the pieces of down and their fibres) to reced from one another and the bar; in like manner as the threads in the ſeventh experiment, ſection third. If any non-electric body be held near the pieces of down whilſt they are in the above circumſtances they will be moved towards the non-electric, and immediately after towards the bar, then back again, and ſo on continually, and very quick, whilſt the bar is continued to be electrified.

EXPERIMENT II.

On the contrary, inſtead of holding the pieces down towards the bar, let them be held towards the frame of the machine or the perſon who turns the wheel (the machine and perſon turning the wheel, being now ſet upon wax) and one of the pieces of down will be moved towards that part of the perſon or the frame of the machine it is neareſt to; and the down will continue to touch it, whilſt the other piece will be ſtretched out towards the neareſt non-electric, which is in contact with the earth. And if a non-electric body be brought in like manner equally near the laſt mentioned piece as in the other experiment, there will be no ſuch appearance as that of their being moved too and fro between the bar and the non-electric body. But on the contrary, the pieces of down will be extended between the non-electric and the bar, and continue ſo, whilſt the wheel is continued turning.

EXPERIMENT III.

Again, if the machine and perſon be electrified in like manner as the bar (by another machine) upon holding the pieces of down as in the ſecond experiment, they will be moved too and fro between the machine and the non-electric, in like manner as they were between the bar and the non-electric in the firſt experiment. If a non-electric approach any part of the frame of the machine, as in the ſecond experiment there will iſſue an exploſion equal (if not greater) to that when the ſame body approaches the machine in like manner as in the third experiment, or the bar in the firſt experiment. Now ſince nearly ſimilar effects, with reſpect to the exploſion, are produced in the firſt, ſecond, and third experiments, and at the ſame time quite oppoſite effects, with reſpect to the repulſive power; there being no ſigns of the electric matter being accumulated either in the machine, perſon, or the pieces of down in the ſecond experiment; the machine and perſon in the ſecond experiment, are neither of them electrified: or in other words, the machine and perſon have not received a greater quantity of electric matter than originally belonged to them, but on the contrary have loſt part of their original quantity of electric matter.

N.B. WHEN a body has loſt any part of its original quantity of electric matter, in ſuch circumſtances the electric matter in that body may be ſaid to be *attenuated.*

COROLLARY I.

FROM hence it follows, that a free communication with the earth is neceſſary to cauſe and continue an accumulation of electric matter

ter in non-electric bodies; friction alone not being ſufficient.

COROLLARY II.

HENCE alſo the exploſion and ſenſation will be greater when a perſon electrified touches any body whoſe original quantity of electric matter is made leſs or attenuated, than when the ſame perſon touches any body whoſe original quantity is neither attenuated, or made greater: which effect is quite oppoſite to that mentioned in the latter part of the fifth experiment, ſection ſecond.

PROPOSITION V.

THE original quantity of electric matter in a non-electric body, in certain circumſtances, cannot be *attenuated*, or made leſs in that body, beyond a certain degree.

EXPERIMENT.

LET every circumſtance be the ſame in this experiment as it was in the experiment following the third propoſition, and then cauſe the wheel to be turned as before, after a number of turns of the wheel (ſuppoſe forty) light bodies will be moved towards the machine from a certain diſtance: and if any part of the machine be approached by a non-electric, there will enſue a certain exploſion: continue the friction for any length of time, and theſe effects will not differ; that is, light bodies will not be moved from greater diſtances, nor will the exploſion be larger.

PROPOSITION VI.

The electric matter cannot be *accumulated* in a non-electric body beyond a certain degree, in certain circumſtances.

Experiment.

Let the bar BB, or any other non-electric body, placed on wax, or reſin, or ſuſpended by ſilk lines, be electrified by a few turns of the wheel; and a light body will be moved towards it from a certain diſtance, and if two threads are electrified, as in the ſeventh experiment, ſection 3, they will recede from one another to a certain diſtance; continue the electrification for any length of time, and there will be no apparent difference: that is, a light body will not appear to be moved towards the bar from a greater diſtance, nor will the threads appear to recede further from one another, neither will the exploſion be any larger when the bar is approached by a non-electric,

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SECTION V.

PROPOSITION. VII.

THE accumulation of electric matter in a non-electric body, in *ſome* circumſtances, ſeems to be directly proportional, and in *other* circumſtances reciprocally proportional, to the reſiſtance it meets with as it tends to expand and diſſipate; provided that in each caſe the reſiſtance does not exceed a certain degree.

EXPERIMENT I.

WHILST the wheel is turning, and the bar BB (which is now ſuppoſed pointed at each end) conſtantly electrified, a light will be ſeen to iſſue from the extremities thereof; and if one of the extremities has a finer point than the other, the light will iſſue moſt copiouſly from that point; but there will be no ſuch appearance in any part of the ſurface of the bar: nor will the bar be electrified to a greater degree, though the friction be continued ever ſo long. On ceaſing to electrify the bar, that inſtant (to all appearance) the light at the point ceaſes; and if a perſon brings a non-electric near the point, the light will again iſſue for a very ſhort time, after which there will be no appearance of electric matter remaining in the bar.

EXPERIMENT II.

IF the bar be cylindrical, and an inch and an half, or two inches in diameter (which we have ſuppoſed all along) and have one of its ends rounded evenly off, on electrifying it, there will iſſue a light from that end only which is pointed, and the bar will be ſomewhat more ſtrongly electrified.

EXPERIMENT III.

IF the pointed end of the bar be alſo rounded evenly off, in like manner as the other end, there will be no appearance of light either from the ſurface or thoſe rounded extremities; and if the wheel ceaſe from turning, the bar will continue longer electrified, than in either of the two laſt experiments: ſo likewiſe the exploſion will be larger, and louder; and conſequently, the bar will be more ſtrongly electrified, than in either of the two laſt experiments: which degree of electrification can never be made greater by continuing the turning of the wheel.

OBSERV. I. From theſe three laſt experiments it appears, that points reſiſt the exit of the electric matter leſs, than ſurfaces; and that the bar, in the ſeveral circumſtances mentioned in thoſe three experiments, is not capable of receiving a greater quantity of electric matter, than what is produced by a few turns of the wheel.

EXPERIMENT IV.

IF the fineſt pointed needle that can be had (or any other angular termination, or edge of a non-electric body equally fine) be held at ſome diſtance, ſuppoſe eighteen inches, or thereabouts, from the bar, by a perſon ſtanding upon the earth with the point towards the bar, whilſt the bar is electrifying, light bodies will not be moved from ſo great diſtances towards the bar, nor will the exploſion be ſo great on a perſon's touching the bar with his finger, as when the needle is taken away.

EXPERIMENT V.

MOVE the point of the needle nearer the bar (the electrification being continued) and theſe effects will be more apparent; that is, light bodies will not be moved from ſo great diſtances, nor will the exploſion be ſo large as in the laſt experiment.

EXPERIMENT VI.

IF the point of the needle touches the bar, light bodies will not appear to be moved towards the bar, though placed very near the bar. And if the bar be approached by a piece of metal, or the finger of a perſon, no exploſion will enſue.

Observ. II. From the fourth, fifth, and ſixth experiments it appears, that the electric matter diſſipates faſter, the nearer pointed bodies (or other edges or angular terminations of non-electric bodies equally fine) are brought to bodies electrified.

Experiment VII.

If inſtead of the needle point, the end of a body which has no point, or ſharp edge, ſuppoſe the head of the needle, or the end of a thick wire, evenly rounded off, be oppoſed towards the bar at the ſame diſtance the point was oppoſed in experiment the fourth, light bodies will be moved towards the bar from much greater diſtances than thoſe mentioned in that experiment: and the exploſions from the bar will alſo be greater.

Experiment VIII.

Move the end of the wire, or the thick end of the needle, conſiderably nearer the bar, and then the effects will be nearly the ſame with thoſe mentioned in the fourth experiment.

Experiment IX.

If the end of the wire, or the thick end of the needle be ſtill moved nearer, till it be in contact with the bar, the effects to appearance will be the ſame with thoſe mentioned in the ſixth experiment.

Observ. III. From the ſeventh and eighth experiments, compared with the fourth and fifth experiments, it appears that the electric matter in the bar is diſſipated faſter by the approach of bodies finely pointed, than of bodies that are rounded off, or have not points equally fine when oppoſed at equal diſtances. But when either kind of bodies is in contact with the bar, the effects are the ſame.

EXPERIMENT X.

If a much larger ſurface than the end of the wire, or the edge or angular termination of any other non-electric body, equally blunt, be oppoſed at the ſame diſtance from the bar as mentioned in the fourth experiment (ſuppoſe the head of an iron poker) which is round and large, on electrifying the bar again, the exploſion from the bar, on a perſon's approaching it with a piece of metal, or his finger, will, to all appearance, be the ſame as when when the poker is taken away intirely; ſo alſo light bodies will be moved from equal diſtances, whether the poker be held there or not; nor will there be any difference if the palm, or back of a perſon's hand, or any other larger ſurface be oppoſed at the ſame diſtance.

EXPERIMENT XI.

Move the end of the poker, or the ſurface of the hand, half way nearer towards the bar, that is, about nine inches, and the difference, whatever it may be, will not be perceivable.

EXPERIMENT XII.

BUT move either of them conſiderably nearer the bar; and there will be a difference; which difference (at a proper diſtance) will be the ſame nearly with that mentioned in the fourth experiment.

EXPERIMENT XIII.

IF either of them be in contact with the bar, the effect to appearance will be the ſame with thoſe mentioned in the ſixth and ninth experiments.

OBSERV. IV. From the tenth, eleventh, and twelfth experiments, and the fourth, fifth, ſeventh and eighth experiments, it appears that the electric matter in the bar is not diſſipated ſo faſt by oppoſing large ſurfaces at ſome diſtance from the bar, as by oppoſing leſſer ſurfaces at the ſame diſtance. And from the ſixth, ninth, and thirteenth experiments it appears, that the electric matter in the bar is diſſipated equally faſt (to appearance) in each experiment when the bodies are in contact with the bar.

EXPERIMENT XIV.

IF the perſon holding the needle (or any other angular termination, or edge of a non-electric body equally fine) ſtands now upon a thick cake of wax, with the point of the needle towards the bar, at the ſame diſtance with that mentioned in the fourth experiment; on electrifying the bar, the perſon holding the needle will be electrified alſo, but not to an equal degree with the bar; as appears from another perſon's approaching each of them ſeparately with his finger: there iſſuing a larger exploſion from the bar, than from the perſon who ſtands on the wax.

EXPERIMENT XV.

IF the point be moved nearer the bar, the perſon then will be more ſtrongly electrified, but not yet to an equal degree with the bar.

EXPERIMENT XVI.

IF the point be in contact with the bar, then the bar, needle, and perſon, will all appear equally electrified.

OBSERV. V. From the fourteenth, fifteenth, and ſixteenth experiments, it appears that the electric matter paſſes by the needle into the perſon holding it: conſequently, if the perſon did not ſtand on wax, the electric matter would paſs, and be diſſipated in the earth by experiment third, ſection ſecond, as well as by the ſixth, ninth, and thirteenth experiments in this propoſition.

EXPERIMENT XVII.

IF inſtead of the point the perſon turns the thick end of the needle, or wire, towards the bar, but at an equal diſtance from it with that mentioned in the fourth or fourteenth experiments, he will not be ſenſibly electrified.

EXPERIMENT XVIII.

MOVE either of them conſiderably nearer the bar, and he will be electrified in a ſmall degree.

EXPERIMENT XIX.

LET the thick end of the needle or wire be in contact with the bar, and the bar, wire, and perſon, will appear equally electrified, and to the ſame degree with the ſixteenth experiment.

EXPERIMENT XX.

IF, inſtead of the wire, the poker be oppoſed at the ſame diſtance as mentioned in the fourth or fourteenth experiments, the perſon holding it will not be electrified.

EXPERIMENT XXI.

LET him move it half way towards the bar, that is, nine inches, ſtill there will be no appearance of electric matter in the perſon.

EXPERIMENT XXII.

IF he moves it nearer the bar, he will be electrified, but in a leſs degree than the bar.

EXPERIMENT XXIII.

IF the poker be in contact with the bar, the bar, poker, and perſon holding it, will be equally electrified; which in this reſpect is the ſame with the ſixteenth and nineteenth experiments.

Observ. VI. From theſe laſt experiments it appears, that large ſurfaces reſiſt the *entrance*, as well as the *exit* of the electric matter more, than leſſer ſurfaces; ſuch as points, edges, and angular terminations. And therefore from the whole of theſe experiments it ſeems, that the accumulation of electric matter in bodies, in certain circumſtances, is directly proportional to the reſiſtance it meets with as it tends to diſſipate.

We are now to ſhew, that in other circumſtances the accumulation of electric matter is reciprocally proportional to the reſiſtance it meets with as it tends to diſſipate.

Experiment XXIV.

Take a clean dry thin vial V (fig. 5.) which will hold about a pint, or more, and fill it with filings of iron, or water; then put a cork into the neck of it, and puſh a thick wire w thro' the cork into the vial amongſt the filings (if water be made uſe of the wire muſt touch it) and bend the outer part of the wire w, ſo that it may be hung upon any thing as occaſion may require. This being done, hang it on the bar B B, and let nothing touch the outſide of the vial: then, electrify the bar for any time, ſuppoſe forty turns of the wheel; after which, ſtop the wheel, and take the vial off from the bar, and ſet it on wax: or, which amounts to the ſame, let the vial be taken off from the bar very quick whilſt the wheel is turning, and immediately ſet upon wax as in the other caſe; and the filings, or water, will (to all appearance) be no more electrified than the bar itſelf. This is known from the various methods of determining the degree of electrification deſcribed in the firſt ſection, as

1. The explosions from the wire w upon a perſon's approaching it for any number of times, will never exceed the exploſions from the bar B B, when approached in the ſame manner.

2. If the wire w be held for any time by a perſon ſtanding on wax (when the vial is taken off from the bar) he will be electrified in ſo ſmall a degree as ſcarce to be perceived. The ſame thing happens, nearly, if the bar be held in like manner by the perſon, the turning of the wheel being diſcontinued.

3. If the room be dark (which we ſuppoſe the caſe whilſt all the experiments are made that belong to this ſeventh propoſition) and the end of the wire w approached by a non-electric, a very faint light will appear to iſſue from it for a very ſhort time. The like effect will appear from the bar B B, provided one end

thereof be as ſmall as the end of the wire, and ſhaped alſo like it.

Lastly, If a non-electric body be brought near either to the wire, or the bar, all ſigns of their being electrified will preſently diſappear, and nearly in the ſame time.

Experiment XXV.

Hang the vial again upon the bar, and let a perſon ſtanding on the earth, take hold of the outſide of the vial, and electrify again by turning the wheel an equal number of times: then ſtop the wheel, and take the vial off, and ſet it on wax as before: or let the vial be taken off from the bar very quick (whilſt the wheel continues turning) and ſet upon wax; the filings within the vial will be electrified to a much greater degree than in the laſt experiment. But the bar will be electrified in no greater degree than it was in the firſt experiment. The difference between this, and the firſt experiment may be determined by any of the ſame methods. For example,

If the firſt method be made choice of, there will iſſue a large number of exploſions from the wire w, and only two or three at moſt from the bar.

If the ſecond be tried, not only one perſon, but ſeveral perſons will be electrified, and that in a very ſenſible degree: provided they all ſtand on wax, and hold one another, and any one of them the wire w: which is far from being the caſe, if the bar in this experiment be held in like manner.

If the third method be made uſe of, a larger quantity of light will appear to iſſue from the wire w, and for a longer time than appears to iſſue in the firſt experiment: but the light from the bar in this, is the ſame with that in the firſt experiment.

And if the fourth method be tried, equal differences appear, for the bar will loſe all ſigns of being electrified in the ſame time (to all appearance) it did in the firſt experiment: but the vial will take up a much larger time before the filings and the wire w have loſt all ſigns of being electrified.

There are two other remarkable experiments that alſo prove the accumulation of electric matter to be greater in one caſe than in the other. They are performed with the ſame vial, but filled with water. The vial is to be without a cork; ſo that it may be electrified by a wire hanging upon the bar BB.

Experiment XXVI.

[a] If the vial be brought ſo near to the wire, by a perſon ſtanding on the earth, that the

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[a] This Experiment was firſt made by Dr. *Bevis*.

end thereof touches the water in the vial, and the wheel be turned an equal number of times with the firſt or ſecond experiment, and the vial afterwards taken away from the wire; on pouring only *part* of the water into a metal diſh, which muſt be held by a perſon ſtanding on wax; the perſon will be ſo ſtrongly electrified, that if in his other hand he holds a metal ſpoon with a little warm ſpirit of wine, on the approach of a non-electric towards the ſpirit, it will immediately be ſeen to flame.

EXPERIMENT XXVII.

IF the vial be filled again with water, and ſet upon wax, on electrifying it as in the firſt experiment, and ceaſing to turn the wheel, the water will not be electrified to that degree it was in the third experiment, as may be readily found upon making the ſame trial; for the perſon will not be ſo much as ſenſibly electrified; even though the whole quantity of water be poured into the metal diſh.

HENCE it appears that the accumulation of electric matter is greater in the 25th and 26th experiments than in the 24th and 27th. Now if it ſhall appear that the reſiſtance is leſs in the 25th and 26th than in the 24th and 27th experiments, we may conclude that in certain circumſtances the accumulation of electric matter is reciprocally proportional to the reſiſtance it meets with as it tends to expand and diſſipate.

THAT the reſiſtance given to the exit of the electric matter is greater in the 25th and 26th experiments than in the 24th and 27th, will appear from the following experiments and obſervations.

EXPERIMENT XXVIII.

IF the vial V be hung upon the bar BB (fig. 5.) and nothing touch the outſide of the vial, electrify the bar again, and a light will be ſeen to iſſue from the end of the wire w after the firſt turn of the wheel, or rather before one turn is made; and light bodies will be moved towards the outſide of the vial in like manner as towards the bar, but not at ſo great a diſtance as they are towards the bar. Continue the turning of the wheel, and theſe effects will not be greater nor will the electric matter be accumulated to a greater degree within the vial, than is mentioned in the 24th experiment.

OBSERV. VII. From this experiment it appears that the electric matter cannot be accumulated to a greater degree in the vial in theſe circumſtances: and that leſs electric matter paſſes from the ſides of the vial than from the bar. And therefore the reſiſtance is greater from the vial than the bar.

EXPERIMENT XXIX.

IF a perſon holds the point of the fine needle (or any other angular termination or edge of a non-electric body equally fine) towards the outſide of the vial V, and at the ſame diſtance from it with that in the fourth experiment from the bar, the filings in the vial will be electrified to a much greater degree than the bar, but weaker than that mentioned in the 25th experiment: after which, if the vial be not taken off, and the wheel be continued turning for any time, a light will be ſeen to iſſue from the wire w, in like manner as in the 28th experiment. But the filings will be electrified in no greater degree in ſuch circumſtances than is mentioned in this experiment.

EXPERIMENT XXX.

MOVE the point nearer, and the filings in the vial will be more ſtrongly electrified; and the light at the end of the wire w, will be ſomething longer, as to time, before it can be ſeen to iſſue.

EXPERIMENT XXXI.

LET the point of the needle be in contact with the vial, and the filings will be as ſtrongly electrified as in the 25th experiment, and the time alſo before the light can be ſeen to iſſue from the wire w, will be as long as it was in that experiment.

OBSERV. VIII. From the xxixth xxxth and xxxi^{ſt} experiments, it appears that more electric matter paſſes into the vial than paſſes out from its ſides in any inſtant: and that there are three different degrees of accumulation of electric matter in the filings, which are owing to the different degrees of reſiſtance; the greateſt accumulation being cauſed by the leaſt reſiſtance.

EXPERIMENT XXXII.

IF inſtead of the point the thick end of the needle, or wire, be oppoſed towards the vial at the ſame diſtance with the ivth or xxixth experiment, the filings will only be electrified to an equal degree with the bar; or in other words, the bar and filings would be juſt as much and no more electrified, to all appearance, than if no ſuch body had been oppoſed at that diſtance: ſo that the effects, with reſpect to the exploſions from each, and the light from the wire w, are the ſame as thoſe mentioned in the xxivth and xxvth experiments.

EXPERIMENT XXXIII.

MOVE the thick end conſiderably nearer the vial, and there will be a difference; for the effects now will be nearly the ſame with thoſe mentioned in the xxixth experiment.

EXPERIMENT XXXIV.

IF the thick end be in contact with the vial, there will be a greater difference: for the filings will be more ſtrongly electrified, and to all appearance in the ſame degree with the xxvth and xxxi^{ſt} experiments

OBSERV. IX. From the xxxii^{d} and xxxiii^{d} experiments it appears, that at equal diſtances with thoſe mentioned in the xxixth and xxxth experiments there are different effects cauſed by the different degrees of reſiſtance.

EXPERIMENT XXXV.

IF, inſtead of the needle or wire, the rounded end of the poker, or the palm or back of the hand, be held towards the vial at the ſame diſtance with the fourth experiment, the filings will not be electrified more than the bar. And the light will appear at the end of the wire w, about the ſame time it did in the xxviiith experiment.

EXPERIMENT XXXVI.

MOVE the poker or hand half as near again, that is about nine inches, and there will be (to all appearance) no difference.

EXPERIMENT XXXVII.

BUT move it nearer, and there will; for the filings will be more ſtrongly electrified than the bar: beſides, there will be a ſmall interval of time before the light appears at the end of the wire w.

EXPERIMENT XXXVIII.

On bringing the poker or hand in contact with the vial, the filings will appear to be electrified to as great degree as they were in the xxvth xxxi^{ſt} and xxxivth experiments, and the light, before it is ſeen to iſſue from the wire w, will be much about the ſame time it was in thoſe experiments.

OBSERV. X. From the xxxvith and xxxviith experiments it appears, that at equal diſtances with thoſe mentioned in the xxixth xxxth and xxxii^{d} experiments, there are other degrees of reſiſtance cauſed, and different degrees of electric matter accumulated.

EXPERIMENT XXXIX.

If the perſon, inſtead of ſtanding on the earth, now ſtands on *wax*, as in experiment xiv. and oppoſes the point of the needle towards the vial at the ſame diſtance as was done in the ivth and xxixth experiments, the perſon will be electrified in a ſmall degree weaker than the bar; and the filings will be electrified in a ſmall degree greater than the bar: ſo that the accumulation of electric matter in the filings will be conſiderably leſs than the accumulation in experiment xxix. And if the vial in this experiment be not taken off, and the wheel be continued turning for any time, a light will be ſeen to iſſue from the wire w, in like manner as in the xxviiith experiment, but not ſo ſoon as in that experiment, yet ſooner than in the xxixth experiment.

Experiment XL.

Move the point conſiderably nearer, and the perſon will be more ſtrongly electrified, ſo will the filings in the vial: and there will, after a ſhorter time than in the xxixth experiment or xxxth, iſſue a light from the end of the wire w. The degree of accumulation of electric matter in the filings in this experiment is leſs than the degree mentioned in experiment xxx.

Experiment XLI.

Move the point, ſo as to be in contact with the vial, and the electric matter will be accumulated in the filings to a much greater degree, but ſtill leſs than in experiments xxv. or xxxi. In this caſe it will take up a longer time before the iſſuing of the light from the end of the wire w can be ſeen than it did in the laſt experiment; but leſſer than is mentioned in experiments xxv. or xxxi.

Experiment XLII.

If the thick end of the needle or wire be oppoſed at the ſame diſtance from the vial as in the xxxixth and xlth experiments, the differences of electric matter accumulated will be proportional; but leſs than in thoſe two experiments. And if the wire be in contact with the vial, the accumulation will be the ſame as in experiment xli. The difference of time at which the ſtream of light begins to appear at the end of the wire w in each experiment will alſo be proportional.

EXPERIMENT XLIII.

IF the rounded head of the poker or the palm or back of the hand be oppoſed in like manner at the ſame diſtances from the vial as in the xxxixth and xlth experiments, the differences of electric matter accumulated in each experiment will likewiſe be proportional, but leſs than experiment xlii. excepting when the poker or hand are in contact with the vial, for then the accumulation appears to be the ſame with the experiments xl. and xli.

OBSERV. XI. From theſe laſt experiments it appears, that at equal diſtances with the xxixth, xxxth and xxxiſt experiments, leſſer degrees of electric matter are accumulated by increaſing the reſiſtance, than were accumulated in the xxixth xxxth and xxxiſt experiments, where the reſiſtance was leſs. It alſo appears, that the accumulation of electric matter is the ſame, whether a ſmall or large ſurface de in contact with the outſide of the vial.

EXPERIMENT XLIV.

IF more perſons ſtand alſo upon wax, and communicate with the perſon who holds the needle, wire, or poker towards the vial at the diſtances mentioned in the preceding experiments, the filings will be more ſtrongly electrified at thoſe reſpective diſtances, than they were in theſe experiments: and ſtill more ſo to a limited degree, as the perſons added are more in number. And in each experiment it will be a longer time before the light appears at the wire w.

EXPERIMENT XLV.

THE like difference in proportion will happen when the thick end of the needle or wire is oppoſed (the ſame perſons continuing on wax) at the like different diſtances.

EXPERIMENT XLVI.

THE ſame will happen in proportion when the rounded head of the poker is oppoſed (the ſame perſon continuing on wax) at the like different diſtances alſo.

OBSERV. XII. From theſe experiments it appears, that the accumulation is made greater by making the reſiſtance leſs than it was in experiment xli. And ſince upon the whole by oppoſing either fine points, blunted points, or ſurfaces of non-electric bodies at different diſtances towards electrified bodies, very different

ferent effects are produced, the air between the electric body and the body oppoſed ſeems to be one cauſe, which helps to reſiſt the exit of the electric matter, and occaſion theſe differences.

EXPERIMENT XLVII.

IF the needle or any other ſmall quantity of non-electric matter pointed, have either of its ends *ſtuck* into wax, and afterwards brought in contact with the vial whilſt it is electrifying, the filings in the vial (to all appearance) will be no more electrified than in experiment xxiv.

OBSERV. XIII. From this experiment it appears that the reſiſtance is made very little leſs than in experiment xxiv, as there is not a quantity of non-electric matter to paſs from the vial, and expand itſelf in.

EXPERIMENT XLVIII.

IF the ſame pointed body be ſtuck upon a very thin piece of wax, the oppoſite part of the wax to the fixed point, being in contact with the earth, and the other point at the ſame time brought in contact with the vial, the filings in the vial will be more ſtrongly electrified than in experiment xlvii.

OBSERV. XIV. For the reſiſtance to the paſſage of the electric matter from the vial into the earth is made leſs by the interpoſition of thin wax.

EXPERIMENT XLIX.

IF inſtead of a thick quantity of wax, which we before ſuppoſed the perſon to ſtand on, we make uſe of a quantity that is very thin, as in the laſt experiment, the effects in all reſpects will be very different from what are mentioned in thoſe experiments where the thick wax is made uſe of: for the perſon will not be ſo ſtrongly electrified, the other circumſtances being the ſame; though a greater quantity of electric matter will paſs from the vial. It will be longer alſo before the light at the wire w appears, as well as before light bodies are moved too and from the bar, at the greateſt diſtance. The accumulation of the electric matter in the filings in thoſe circumſtances will alſo be greater at equal diſtances, but leſs than the accumulation in experiment XXV.

OBSERV. XV. From hence it appears, that the reſiſtance is farther varied and made leſs by the thin wax: and yet the reſiſtance is greater, than when no wax is interpoſed: therefore there muſt be ſtill different degrees of accumulation of the electric matter.

EXPE-

EXPERIMENT L.

IF any of the non-electric bodies mentioned in the xli^st^ xlii^d^ and xliii^d^ experiments, are placed in contact with the vial and the earth at the ſame time, a light body placed at a ſmall diſtance from the bar, upon the earth, will not be moved towards the bar at the firſt, ſecond, third, or fourth turn of the wheel. But when the light iſſues from the wire w, then (or a very ſmall interval of time before) the light body will be readily moved to and from the bar very quick.

EXPERIMENT LI.

IF nothing touches, or is near the outſide of the vial, the ſame light body placed at the ſame diſtance from the bar upon the earth will, on the firſt turn of the wheel, be moved to and from the bar very quick.

OBSERV. XVI. From theſe laſt experiments it appears, that the electric matter coming from the machine into the bar, does not paſs ſo readily from the ſides of the bar, as into the filings, until the electric matter is accumulated in the filings to its greateſt degree.

EXPERIMENT LII.

IF the glaſs vial be very thick, then thoſe experiments will not ſucceed; for a very little only of the electric matter will be found to paſs through the glaſs, therefore the effects are very different.

OBSERV. XVII. From this experiment it appears that the reſiſtance may be made too great.

EXPERIMENT LIII.

IF the glaſs vial be exceedingly thin, thoſe experiments will not ſucceed in the manner we have mentioned neither; for the electric matter will be found to paſs more readily thro' the thin glaſs than thro' a thicker glaſs, as we have ſhewn by experiment iii. ſect. ii. and obſerv. xiii. and xiv.

OBSERV. XVIII. From this experiment it appears, that the reſiſtance may be made too *little*.

THE ſame thing is manifeſt from points, and the ſurface of the bar in obſervation i. where it appears that the electric matter paſſes away the quickeſt, where the reſiſtance given to its exit is leaſt.

COROLLARY.

X

FROM the whole it follows, that in order to produce the greateſt accumulation of electric matter, it is neceſſary there ſhould be a certain degree of reſiſtance; and that the reſiſtance ſhould be equal and uniform. For it has been found, that if the glaſs be of an unequal thickneſs, or have a flaw, hole, or crack in it, the electric matter will eſcape more readily through thoſe parts, than through any other part of the glaſs.

THAT this uniform and equal reſiſtance alone is neceſſary for producing the greateſt accumulation will be farther confirmed from the two following experiments.

EXPERIMENT LIV.

IF the vial be covered on the outſide with a non-electric, if points and edges are avoided, on electrifying the outſide thereof only, the ſame effects to all appearance will inſue. This will be determined by a very eaſy method in propoſition xi.

EXPERIMENT LV.

[a] IF a plane of glaſs G (fig. 6.) of the ſame thickneſs with the vial, be covered cloſe on each ſide with a non-electric, ſuppoſe leaf gold, ſilver, braſs, or thin lead t, leaving an inch and an half or two inches uncovered all round the glaſs on each ſide next its edges e e e, on electrifying either ſide, ſuppoſe t, whilſt the contrary ſide is in contact with the earth by means of the non-electric n, the electric matter will be accumulated to as great a degree on the electrified ſide t, as it was in experiment xxv.

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[a] This experiment was made by Mr. *Smeaton.*

Upon the whole, from the preceding experiments, we gather the following general truths, with regard to different bodies reſiſting the paſſage of the electric matter with different degrees of ſtrength.

1. That glaſs, wax, and other electric bodies reſiſt or obſtruct the paſſage of the electric matter more than air: provided that the electric bodies are not very *thin.*

2. That one inch of air ſeems to reſiſt leſs than one foot of air; and one foot leſs than three feet; and ſo on.

3. That air in general reſiſts more than the ſurfaces of non-electric bodies.

4. That the ſurfaces of non-electric bodies reſiſt the paſſage of the electric matter more than the obtuſe ends, blunt edges, or obtuſe angular terminations of the ſame kind of bodies.

5. That obtuſe ends and blunted edges or obtuſe angular terminations of the ſame kind of bodies, reſiſt the paſſage of the electric matter more than fine points, ſharp edges, or acute angular terminations of the ſame kind of bodies.

6. That the fineſt points, edges, and angular terminations of non-electric bodies, reſiſt the paſſage of the electric matter *leaſt* of all.

When we hereafter ſpeak of the reſiſtance, or obſtruction of glaſs, wax, air, non-electric ſurfaces, obtuſe non-electrics, or acute or fine points, or edges of non-electric bodies, we would be underſtood to mean that power or reſiſtance, whatever may be its cauſe, which prevents the paſſage of the electric matter more, or leſs, as the bodies made uſe of differ in ſhape and kind.

It may ſeem difficult to conceive, how different degrees of accumulated electric matter in the ſame body are cauſed, by varying the reſiſtance the fluid meets with in its tendency to diſſipate, as was ſhewn in the proof to the laſt propoſition, ſince it appears that the leaſt accumulation is cauſed when the reſiſtance it meets with is increaſed, and the greateſt accumulation when the reſiſtance is decreaſed.

Now ſome perhaps may think that theſe ſurpriſing effects are owing to an attractive power of the earth, acting variouſly in different circumſtances, and that the accumulation is proportional to the attractive power.

But were this ſuppoſition true, pointed bodies oppoſed to the vial at ſome diſtance, in the manner we have treated of, ought to produce the leaſt accumulation of electric matter in the vial when compared with ſurfaces oppoſed at the ſame diſtance and in the ſame circumſtances.

cumſtances; whereas by experiment it is found they produce the greateſt: and when any pointed body is in contact with the vial, the effects are the ſame with reſpect to the accumulation as when a ſurface is in contact with the vial, and in the ſame circumſtances: therefore thoſe effects muſt ariſe not from an attractive power, but from the reſiſtance the fluid meets with in tending to diſſipate and expand itſelf.

We have ſhewn how to accumulate electric matter in the vial; we will now ſhew how the original quantity of electric matter in the ſame vial may be leſſened or attenuated.

Experiment.

Set the machine on wax, and let a perſon ſtanding on the earth take hold of the outſide of the vial, and inſtead of hanging it upon the bar B B, by the wire w, let that wire touch any part of the frame of the machine, or the perſon turning the wheel, who alſo muſt be on wax. Let a wire, or any non-electric body communicate with the bar B B and the earth, after forty or fifty turns of the wheel, take the vial away, but, whilſt it continues turning, and afterwards, ſet it upon wax. And the original quantity of electric matter in the filings within the vial, will appear to be attenuated to ſuch a degree, as to produce effects equally ſtrong with thoſe mentioned in experiment xxv. where the electric matter was accumulated.

ALL the effects we yet know of, ariſing from this attenuation, are the ſame with thoſe produceable from the accumulation; excepting that remarkable difference of the acceding and receding of light bodies particularly related in the experiments following propoſition iv. which hold equally true in this caſe.

PROPOSITION VIII.

The electric matter, when accumulated, ſeems to be diſſipated, on cauſing an exploſion, not only through the part where the exploſion is made, but through the whole ſurface of the body, even though an electric body be interpoſed, provided it be thin.

EXPERIMENT I.

[a] Let a thin plate of glaſs ten, fifteen, or twenty inches ſquare be gilt with leaf gold on each ſide (or covered with ſheet lead) within two inches of the border; or rather, let the thin glaſs vial V (that being moſt commonly uſed) which is filled with filings of iron, be covered cloſe on the outſide with ſheet lead, leaving about two inches and a half uncovered at

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[a] This experiment was made by Mr. *Canton* Maſter of an Academy in *Spittle Square*, *London*.

the neck. Electrify the matter within, by means of the wire w paſſing through the neck of the vial, whilſt the outſide covering is held by a perſon ſtanding on the earth. When it is electrified, ſet the vial upon any electric body R; this done, approach the wire w with your finger, and there will be an exploſion; upon repeating it, a ſecond, and a third will enſue, and ſo on. The like will happen on approaching the external leaden covering; when you have touched that ſo often till the exploſions ceaſe, approach the wire w again and an exploſion will again enſue; after this, you will have another from the outward covering; and ſo alternately from each, until the whole accumulated matter is nearly diſſipated.

EXPERIMENT II.

If the non-electric covering on the outſide of the vial be but half an inch, or an inch in extent, theſe effects will be leſs from the covering than in the other caſe where the covering is larger.

EXPERIMENT III.

If the glaſs be very thick, theſe effects are not produced.

These phænomena ſeem to be owing to the force of the exploſion; for as the exploſion ſeems to be made only when the electric matter is ſufficiently condenſed, or collected into a kind of focus, and as action and re-action are equal, the particles next in ſucceſſion to thoſe in the focus may be ſuppoſed to be checked or repelled, and thoſe to check or repel one another with equal force. By which means thoſe particles lying neareſt the ſurface of the glaſs within the vial, may be forced through the thin glaſs into the non-electric body on the outſide. And conſequently if a non-electric cover the greateſt part of the ſurface of the glaſs, and the glaſs itſelf be of an *even thickneſs*, the particles muſt be forced *equally* into the non-electric from all parts alike. Now ſuppoſing this the caſe, the greater the exploſion is, the greater muſt be the check, or repelling force; and conſequently the more the electric matter forced through the glaſs into the ſurrounding covering.

And again, the greater or leſs the non-electric covering on the glaſs is, the greater or leſs alſo muſt be the quantity of electric matter forced through the glaſs into the covering. All this we find to be true in fact.

Corollary I.

If this reaſoning be true with reſpect to the effects produced by the exploſion where a thin electric is interpoſed, it ſhould hold equally true where the electric body is not interpoſed, as in that caſe the reſiſtance is leſs. And therefore we ſuppoſe that when the bar is electrified, and an exploſion cauſed, all the electric matter that does paſs off from the bar at that inſtant, does not paſs out at the point, or part where the exploſion is made, though the moſt conſiderable part may eſcape there, but from every part of the ſurface; provided the reſiſtance in all the parts of the ſurface be equal.

THIS equality of reſiſtance may be had the neareſt by making uſe of any poliſhed metalline body which is ſpherical.

THE accumulation of electric matter in the vial, bar, or ſphere, is not totally diſſipated by repeated exploſions, as appears from the following experiment.

EXPERIMENT.

FIX a fine downy feather upon the wire of the vial, bar, or ſphere; when they are electrified, approach them with a non-electric till the exploſion ceaſe: after which approach the feather and ſome of the fibres will move towards the non-electric and continue to do ſo upon the repeated approaches for ſeveral times.

WHEN one part of a non-electric body, or bodies but in contact with one another, ſuppoſe D, touches one ſide of an electric V, which has oppoſite on its other ſide a non-electric C in contact with it, and another part of the ſame body D is brought near the laſt mentioned non-electric C: the body D ſo diſpoſed, together with the electric V, and the oppoſite non-electric C, we call the [a] *circuit*, and in ſuch circumſtances we ſay the circuit is completed. And the non-electric D completing the ſame, we call the *diſſipator*.

THE electric V is repreſented by the vial V, (fig. 7.) The diſſipator D, by the crooked bar of iron, wire, or chain, D. And the non-electric C, by the filings within the vial V and its wire w.

PROPOSITION IX.

WHEN electric matter is accumulated in the filings to the greateſt degree, the loudneſs of the exploſion and quantity of electric matter diſſipated on completing the circuit, ſeem in ſome meaſure proportional to the points of non-electric contact with the *out* and *in* ſide of the vial.

PROOF BY EXPERIMENTS.

EXPERIMENT I.

WHEN the filings in the vial are electrified to the greateſt degree, let the diſſipator have that end very ſmall which is to be in contact with the vial; on completing the circuit, there will be an exploſion, but not a large one. If the circuit be completed a ſecond or a third time, the ſecond exploſion to appearance will be the ſame with the firſt, and the third will be rather weaker, and ſo on, till nearly the whole accumulated electric matter is diſſipated.

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[a] This term was made uſe of the firſt by Mr. *Watſon*.

EXPERIMENT II.

IF the diſſipator have that end much broader which is to be in contact with the vial (ſuppoſe two or three inches) the firſt exploſion will be larger, and the ſecond and third much leſs.

EXPERIMENT III.

IF the diſſipator have that end next the vial ſo broad as to be in contact with the vial in every part for the compaſs of ſix or ſeven inches ſquare, the firſt exploſion will be much greater than the firſt, and the ſecond much leſs than the ſecond in the laſt experiment.

EXPERIMENT IV.

INSTEAD of filling the vial with filings, let there be only a very ſmall quantity thereof in the vial, or let the inſide non-electric contact with the vial be no greater than in the firſt experiment, and afterwards that non-electric electrified; on completing the circuit with the ſame point of the diſſipator oppoſed to it, there will be no viſible exploſion.

EXPERIMENT V.

INCREASE the contact in the vial, ſo that it may equal the contact on the outſide thereof mentioned in the ſecond experiment: on electrifying the inſide and completing the circuit with the ſame point of the diſſipator on the outſide, an exploſion will be produced, but leſs than that in the firſt experiment.

EXPERIMENT VI.

If the contact on the outſide be increaſed ſo that it may equal the contact in the inſide mentioned in the firſt, ſecond, and third experiments; and the inſide contact be no greater than the outſide in the firſt experiment; the effects will be the ſame with thoſe mentioned in that experiment.

EXPERIMENT VII.

If the inſide and outſide contact are alike, and equal to the outſide contact in the ſecond experiment; the effects will be leſs than thoſe mentioned in the ſecond experiment, but greater than in the firſt experiment.

If the inſide contact be equal to the outſide contact in the ſecond experiment, and the outſide the ſame with the ſecond experiment; the effect will be the ſame with thoſe mentioned in that experiment.

From theſe experiments it appears, that the greater the ſurface of a non-electric body is which touches the outſide of the vial when filled with filings, the greater the exploſion and diſſipation. And that the leſs the ſurface is, the leſs are thoſe effects: but the greater the ſurface of the non-electric, the greater the quantity of contact, and *vice verſa.* Therefore the propoſition is true.

THIS is farther confirmed by propoſition viii. with its proof and experiment lv. propoſition vii.

SECTION VI.

WE have ſhewn what effects ariſe from a non-electric body when it is in contact with the outſide of the vial. We will now cover the outſide of the vial with a non-electric properly, by which means it will be better fitted for more extraordinary experiments, and the vial, when covered, may be ſaid to be properly prepared.

To do this, take the ſame vial made uſe of before, or let a quart or larger vial V of the thinneſt kind, and as *equally* ſo as can be had (the longeſt kind are the propereſt) be almoſt filled with clean filings of iron, quickſilver, granulated lead, or water: if it be with filings of iron, take care that they are ſhaked together very well, ſo that they may lie cloſe to the ſides of the glaſs; then put a cork into the neck of it, and force the wire w through the cork into the filings. The wire w ſhould be very thick, and the outer end rounded off. After this, wax all the cork which is without the vial. Now take a clean thin piece of milled, or ſheet lead (ſuch as comes from *India* in which tea is brought) as much as will wrap twice round the vial, and cover the ſurface of the vial from the bottom to within two inches and an half of the cork. Roll this piece which we call the *covering*, very tight round the vial, and afterwards bind it very well with one continued piece of wire, well nealed; and where you diſcontinue the binding, make a loop X for a bar, chain, or wire D, to be hooked on, as occaſion may require.

Now any part of this covering, or the loop X, may be touched with the diſſipator (when the circuit is to be completed) for the effect will be the ſame[a].

N.B. If the vial could be covered over with quickſilver in the manner looking-glaſſes are, or with any other non-electric body without points or edges, it would be preferable to the leaden covering and its binding wire.

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[a] This method of covering the vial with *lead* was diſcovered by Dr. *Bevis*, which is indeed preferable to mine with water, which I at firſt made uſe of, as it is more convenient to manage.

PROPOSITION X.

WHEN the electric matter is accumulated in the vial to the greateſt degree, the greateſt effects are produced by completing the circuit.

EXPERIMENT.

Let the filings in the coated vial be electrified to the greateſt degree poſſible under ſuch circumſtances (ſee experiment xxv. ſection v.) then if a perſon with one hand touch the covering of the vial, and with the other approach the wire w at the ſame time, he will receive a much more painful ſhock, than if he approached the wire w only (here we ſuppoſe the vial to continue hanging upon the bar or ſet upon wax.) If horſes, oxen, ſheep, dogs, or any other animals be the diſſipator or part of it, they appear to be affected in like manner. The exploſion alſo will be much greater, and the accumulated matter will be in a manner totally diſſipated.

THE exploſion will be ſtill ſomething greater, and the accumulated electric matter will be alſo in a manner totally diſſipated, if a ſingle piece of iron be the diſſipator inſtead of the perſon.

IT has been already ſhewn (by propoſition viii.) that when the vial is electrified and placed upon an electric body, the approaching of the wire w only will not diſcharge the whole of the accumulated electric matter: nor indeed will it make any apparent difference, as ſome perhaps might imagine, if the covering be touched and the wire w approached at the ſame time, but with ſeparate bars of iron equal in weight to the quantity of non-electric matter contained in the vial; nor even ſuppoſing the bars or other non-electric matter to be increaſed to any quantity whatſoever. But when the external covering is touched at the ſame inſtant of time that the wire w is approached, either by two different bodies of the ſame kind, but in contact with each other, or by one only, and that either large or ſmall, which we have called the diſſipator, the caſe is then widely different, for the electric matter is in a manner totally loſt and diſſipated.

How this is effected is not eaſy to ſay, nor ſhall we take upon us abſolutely to determine, being as yet not thoroughly ſatisfied from experiments. However, in order to aſſiſt thoſe who may purſue theſe inquiries farther, we ſhall ſet down ſeveral experiments of different kinds, and from them propoſe a query how the completing the circuit ſeems to cauſe ſo ſudden and great an exploſion and diſſipation of the electric matter.

EXPE-

EXPERIMENT I.

WHEN the filings in the vial are electrified to the greateſt degree (which in each of the following experiments we ſhall always ſuppoſe to be the caſe) ſet the vial upon a cake of wax, and let nothing touch either the vial or the wire w, and it will be a conſiderable time before the electric matter will be diſſipated.

EXPERIMENT II.

LET the vial ſtand on the earth and there will be (to all appearance) but a very little difference; the electric matter taking up rather a leſs time before it is diſſipated, than in the firſt experiment.

EXPERIMENT III.

SUPPOSE the vial for this one experiment to have any part of the bottom or ſides ground *extremely thin*, and to be electrified to an equal degree with the foregoing experiments; in order to do this, let ſome ſealing-wax be put upon the thin place whilſt it is electrifying, and after the vial is electrified, take the ſealing-wax away, and ſet the vial on the earth; ſo that a non-electric may touch the thinneſt part of the glaſs and the earth at the ſame time. The accumulated electric matter in theſe circumſtances, will be diſſipated nearly in half the time it will in the firſt or ſecond experiment.

EXPE-

EXPERIMENT IV.

WHEN the filings within the vial V are electrified and ſet on any electric R, if a perſon ſtanding on the earth, touch with his hand, or hold the wire w that paſſes into the vial, for ſome time, he will cauſe the whole of the accumulated matter within the vial to be diſſipated in a ſhorter time than in the firſt or ſecond experiment.

EXPERIMENT V.

LET a fine feather, whoſe fibres are long and ſlender, be fixed upon the bar B B, and let the bar be electrified; when it is, ceaſe to turn the wheel, and the fibres of the feather will move towards a non-electric when approached near it, though a perſon ſtanding upon the earth continues to hold the bar in his hand for ſome time. This experiment is ſimilar to the laſt experiment, and as ſuch we have introduced it here.

EXPERIMENT VI.

AGAIN, inſtead of touching the wire w with his hand, as in the fourth experiment, let him hold the point of a needle in contact with the wire after the vial is electrified, and ſet upon wax, in this caſe the whole of the electric matter will be diſſipated in a very ſhort time compared with the firſt, ſecond, third, or fourth experiment laſt mentioned.

EXPERIMENT VII.

IF the ſixth experiment is repeated with the ſame circumſtances, except that the perſon now ſtands upon an electric R, he will be electrified in a ſmall degree, and the whole of the accumulated matter in the vial will not be diſſipated in ſo ſhort a time as in the ſixth experiment.

EXPERIMENT VIII.

WHEN the vial is electrified, ſet it upon the earth, and let a perſon ſtanding upon wax touch the wire w, the accumulated electric matter will not be diſſipated as ſoon to appearance as is mentioned in the ſixth experiment.

EXPERIMENT IX.

ELECTRIFY the vial again, and let the perſon ſtanding on wax now take hold of the covering of the vial inſtead of the wire w, at the ſame time let the wire w touch the earth; and there will be a conſiderable difference; for the accumulated electric matter will now appear to be diſſipated ſooner than is mentioned either in the firſt, ſecond, or eighth experiments, and very near in the ſame time with the fourth experiment.

EXPERIMENT X.

LET the covering of the vial V be brought within an inch and an half or thereabouts of the top of the neck, and let the outward extremity of the wire w be covered with dry wax: ſoon after the vial is filled with electric matter, a light appears to iſſue from the wire at the neck, which light tends towards the covering, and in a little time explodes, provided the wheel be continued turning. After this a ſecond effect equal to the firſt cannot be produced without electrifying again. Nor is there any ſign of electric matter being left within the covering.

EXPERIMENT XI.

AGAIN let there be faſtened to the covering of the vial V, a wire or chain C, one, two, three, or more feet long: and let the vial be electrified to its greateſt degree, and then placed upon wax. If the wire or chain be taken hold of, even with an electric R, and brought by means thereof to the wire w, ſo as to complete the circuit, a large exploſion will enſue, and almoſt the whole accumulated matter will be diſſipated. If inſtead of holding the wire or chain in the manner abovementioned, either of them be dropped upon the wire w, the effects, to all appearance, will in every reſpect be the ſame. In both theſe caſes, after the large exploſion, a ſmall one, or two, may be produced by repeating the circuit, after which no electric matter will be found in the wire or chain C upon a perſon's touching of them.

EXPE-

EXPERIMENT XII.

[a] IF the diſſipator D be a bar, wire, or chain, and there be a piece of gilt leather, about the ſize of a crown, with its edges waxed round, fixed in the middle, either to the approaching part of the diſſipator, or the part of the wire w approached, on electrifying the filings in the vial, and completing the circuit in the middle (or thereabouts) of the leather, a viſible hole will be made through the leather (a ſtrong proof that the electric matter paſſes through bodies) and a loud exploſion will enſue.

EXPERIMENT XIII.

IF the end of the diſſipator D, next the covering of the vial, or the covering it ſelf, have alſo a piece of gilt leather fixed to it at the ſame time that the other piece is on the other end of D, or the wire w, the filings being electrified, on completing the circuit in the middle or thereabouts, of each piece of leather, a hole will be made through each, and to all appearance in the ſame inſtant. In theſe experiments where the circuit is completed, the ſame effects to appearance are produced, whether the diſſipator touches the wire w or the covering firſt.

THE following account is a deſcription of an apparatus like that of the vial with its circuit to condenſe air in. It is ſo contrived that the effects ariſing from condenſed air may be compared with thoſe ariſing from the accumulated or condenſed electric matter in the electrified vial.

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[a] Dr. *Bevis* obſerved this effect; the experiment he made was much the ſame with this.

LET V (fig. 9.) repreſent a veſſel of glaſs; W a hollow pipe exhauſted of air fitted cloſe to the neck of the veſſel V, ſo that no air can eſcape: one end of which opens into the veſſel, the other end has a ſtop-cock at n. Let D D repreſent another hollow pipe communicating with V at z; and with W at y, like the diſſipator: at which places there are alſo ſtop-cocks. And let there be alſo another ſtop-cock at x.

CASE I.

SUPPOSE now theſe ſtop-cocks x y and z turned, or ſhut, ſo that no air can paſs from V into the pipe D D, or through x into the air without. Condenſe four atmoſpheres of air into the veſſel V through the ſtop-cock n: then turn the cock n till the aperture in it is almoſt cloſed, and only a very little air eſcapes through it. If the time from its firſt beginning to iſſue to the time it ceaſes to iſſue be now examined, it will be found to be very conſiderable. See the firſt experiment, propoſition i.

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CASE II.

SUPPOSE every thing as before, but inſtead of letting the condenſed air eſcape through n into the open air without, let it eſcape through the ſame aperture into an exhauſted receiver, which held, before it was exhauſted, more air than is condenſed in V. And it will take up a ſhorter time to eſcape or expand itſelf in to the ſame degree, than it did in the firſt caſe. See the fourth and fifth experiments, propoſition x.

CASE III.

CONDENSE the ſame number of atmoſpheres into the veſſel again, and turn the cock n as before, leaving, as near as can be judged, the ſame, or an equal paſſage for the condenſed air to eſcape into the open air: immediately after this, ſuppoſe the ſtop-cock x to be turned, leaving alſo a paſſage for the air to eſcape through it as it did from n, but ſomewhat larger. The ruſhing out of the air then through each paſſage will not be equal, but rather greater from x than n: therefore the condenſed atmoſpheres will eſcape, or paſs out through theſe two paſſages or apertures in x, and n, nearly in half the time they did from a mean between the firſt and ſecond caſes. See the third experiment, propoſition x.

CASE IV.

SUPPOSE now the paſſage for the air to eſcape, at n (the veſſel being again equally filled with air) to be a little larger than the paſſage for the air to eſcape at x, the aperture at x continuing the ſame as in the laſt caſe, then the greateſt quantity of air will eſcape from n: and the time it will take up before the condenſed air has eſcaped through both, will be ſhorter than in the laſt caſe. See the ſixth and ninth experiments, propoſition x.

CASE V.

TURN the cock K ſo that no air can eſcape by it, and condenſe the air again to an equal degree as before, leaving the aperture n as ſmall as is mentioned in the firſt caſe: immediately after this, ſuppoſe y and z to be turned at the ſame inſtant of time, that the air may eſcape into the pipe D D; in this caſe it is eaſy to conceive that there will ruſh out a greater quantity of air in a ſhorter time than in the fourth caſe. See the xth, xith, xiith and xiiith experiments, propoſition x.

IT is manifeſt too, that as the air in the pipe grows denſer and denſer as more ruſhes into it at each end, the entrance of the air will be ſlower and ſlower; as it will be every inſtant more and more obſtructed by reaſon of the denſity encreaſing every inſtant, till it becomes of an equal denſity with that in the veſſel, and then no more can enter the pipe.

Now if the air could be diſcharged the inſtant it attempts to enter the ends of the pipe, it would, by its extreme quick motion, cauſe a ſingle report.

QUERY II. Do not the phænomena produceable from the vial, when the matter within it is electrified, ſquare with theſe experiments relating to air? For as we ſaid before, they appear to be ſimilar as to their elaſticity, and ſo far they ought to be governed by the ſame laws: which indeed ſeems to be the caſe, as thus:

THE vial V filled with air, and the vial V filled with electric matter, are veſſels of the ſame kind; the obſtructions, or different reſiſtances to its paſſing out of the vial, are the ſtop-cocks n, x, y, z: for example, n repreſents the obſtruction ariſing from the wire w; x the obſtruction of the glaſs; y and z are the obſtructions at each end of the body D completing the circuit: and the hollow pipe DD is the diſſipator D, which completes the circuit.

THE firſt caſe, where all the ſtop-cocks are ſhut, except that at n, is ſimilar to the electrified vial placed as in the firſt experiment; for in that experiment the reſiſtance at the wire w may be conſidered as ſimilar to the ſtop-cock at n.

The ſecond caſe, where the exhauſted receiver is fixed to n, is ſomewhat analogous to the fourth and ſixth experiments: for in theſe experiments the reſiſtance was made leſs by the non-electric contact, and here it is greatly leſſened by taking away the air.

The third caſe, in which the ſtop-cocks n and x are near equally opened, is ſimilar to the third experiment, where the reſiſtance given to the paſſage of the electric matter is leſſened by a non-electric touching the thinneſt part of the glaſs.

The fourth caſe, where the ſtop-cock n is more opened than x, is ſomewhat ſimilar to the ſixth and ninth experiments, in which the electric matter is found to diſſipate faſter where the reſiſtance is leaſt.

The laſt caſe may ſerve to illuſtrate the x^th^, xi^th^, xii^th^, and xiii^th^ experiments. For by propoſition viii. the electric matter, on cauſing an exploſion, is found to paſs both by the wire w and the covering. And by the xii^th^ and xiii^th^ experiments, it is found that the exploſion, and quantity of electric matter diſſipated by that exploſion, is greater when the circuit is completed, than when it is not completed: And it is further found that after an exploſion, when the circuit is completed, there is no ſign of any electric matter within the diſſipator.

Query III. Do not theſe things ſhew that the electric matter is diſſipated the quickeſt by this method of completing the circuit? And may not the large exploſion which attends this experiment, be the reſult of ſeveral ſmall exploſions ſucceeding one another ſo quick as to appear but one?

Query IV. Now as action and re-action are always equal, muſt not the original quantity of electric matter within the diſſipator be acted upon immediately after the exploſion, in like manner as is ſhewn in the eighth propoſition, ſo as to produce the ſame effects as if the accumulated electric matter had actually paſſed through the diſſipator?

For two contrary (violent and ſudden) motions, together with the reſtrictive power of the particles themſelves, may be ſufficient to cauſe that ſtrange and painful ſhock or convulſion of the nerves and muſcles, which is generally felt by animals, when they are ſo placed as to make up part of the circuit.

All the circuit experiments, and the experiment following propoſition viii. ſeem to ſhew that this convulſive ſhock is proportional to the magnitude of the exploſion. For the greateſt ſhock is always produced when the exploſion is greateſt; and the leaſt ſhock when the exploſion is leaſt. By parity of reaſoning it follows, that there ſhould be no ſhock where there is no exploſion at the times of completing the circuit: and that it is the caſe, will appear from the following experiment.

EXPERIMENT XIV.

WHEN the filings in the vial are electrified to their greateſt degree, let a perſon ſtanding on wax, take hold of the covering of the vial with one hand, whilſt in the other he holds a non-electric body, finely pointed, ſuppoſe a needle, with the point towards, and within two and a half or three inches of the wire w. By this means there will no exploſion, nor any convulſive ſhock felt by the perſon holding it, yet in a very ſhort time the greateſt part of the electric matter will appear to be diſſipated and loſt.

OF the ſame nature with this laſt is the following experiment.

EXPERIMENT XV.

WHEN the filings are electrified, ſet the vial on wax, and fix the middle of the wire, which in this experiment is to be the diſſipator, in a ſtick of ſealing-wax, leſt any one ſhould imagine the electric matter paſſes into the perſon by this wire: then bring the ends of the wire equally near the covering of the vial and the wire w at the ſame time, ſuppoſe within an inch and a half of each. And if the room be darkened, a ſtream of light will be ſeen at the ends of the wire as long as any conſiderable quantity of electric matter remains within the vial. After this the wire that completes the circuit will not give the leaſt ſign of any electric matter being accumulated within it.

Let it be obſerved, that we cannot conclude from the diverging of the electric matter, which body it iſſues from: becauſe the electric matter, both in paſſing out of a body and paſſing into it, has the ſame appearance.

This is manifeſt not only from reaſon but experiment.

Experiment XVI.

For, if a perſon ſtanding on the earth holds a pointed body near the bar, whilſt the wheel is turning, a light will appear to iſſue and diverge from the point.

Experiment XVII.

Let the ſame perſon now ſtand on wax, and take hold of the bar, and hold the point from the bar, and the ſame appearance of light (ſuch as the divergency) will be at the point.

In the firſt caſe, the electric matter paſſed into the perſon at the point, and in the laſt caſe, the electric matter paſſed out of the perſon at the point.

To ſhew this otherwiſe, let the perſon ſtanding on wax with his arms extended from one another, hold in each hand a needle, and let one of the needles be within a few inches of, and point towards the bar, whilſt the other needle points from the bar. If the bar be electrified, a light will appear at the point of each needle, and ſeem to diverge from each point at the ſame time.

THE next experiment ſeems to illuſtrate all the reaſoning we have advanced in the proof of this laſt propoſition.

EXPERIMENT.

[a] SET the vial, after the filings are electrified, upon a cake of wax, and let a ſmall ball of metal, paſte, clay, or cork, not too heavy, be ſuſpended at the end of a thread (moiſtened with water) hanging from the top of the room in ſuch manner, as that the ball, when in a ſtate of reſt, may be within a few inches of the leaden covering of the vial. Upon a perſon's touching the wire w in the neck of the vial (he ſtanding on the floor) a ſmall exploſion will enſue, and the ball will have moved from its perpendicular, or natural point of reſt,

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[a] An experiment of the ſame kind with this was made by Dr. *Le Monnier* at *Paris*, and communicated along with ſome others to the Royal Society in *London*, by Mr. *Needham.*

towards the covering of the vial, where it will continue as long as the perſon continues to touch the wire (without being repelled) and whilſt any conſiderable quantity of electric matter remains within the vial.

PROPOSITION XI.

If a perſon completes the circuit by taking hold of the covering of the electrified vial with one hand, and by approaching the wire in the neck of it with the other, the greateſt painful ſhock will be always felt in thoſe parts which lie in the ſhorteſt line that can be drawn through the perſon making up the circuit from the outſide covering to the wire. And this is univerſal, ſuppoſing the perſon an uniform non-electric.

In the caſe abovementioned, the greateſt ſhock will be given along the arms and acroſs the breaſt; if a leg and an arm complete the circuit, whether they be on the ſame, or on different ſides, the greateſt ſhock will be given in thoſe parts which lie in the ſhorteſt line of communication between the leg and the arm[*].

N.B. The filings muſt not be electrified to the greateſt degree, leſt the perſon who makes the experiment, ſhould receive any hurt from the violent effects of the electric matter.

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[*] This method of affecting any part of the body without affecting the other parts, I diſcovered in the year 1746.

The ſafe method of trying this experiment, is to make uſe of the vial mentioned in thoſe experiments following the ninth propoſition. And inſtead of covering the outſide of the vial with lead, and completing the circuit with a wire, let the perſon take hold of the uncovered vial, and graſp it cloſe with one hand, whilſt with the other he approaches the wire w; and the effect will be much leſs. And it will be ſtill leſs if the perſon only touches the vial with his finger inſtead of graſping it with his hand by propoſition ix.

PROPOSITION XII.

Non-electric bodies placed without the circuit, will, on completing the circuit, be affected in the ſame manner (but in a leſs degree) as if part of the accumulated electric matter had paſſed into them.

Experiment I.

Electrify the filings in the vial V (fig. 10.) and place the vial in a darkened room upon the wax R, on which lay likewiſe in any direction ſeveral pieces of iron c, d, e, f, g, in ſuch a manner, that the firſt piece c may touch the outſide covering of the vial V, and that the reſt may not be diſtant from each other above $\frac{1}{20}$ of an inch. Approach the wire w which is in V with one end of the iron rod r, the other end reſting upon c, and you will have an exploſion, not only from the iron rod, but from the ſeveral pieces of iron c, d, e, f, g.

EXPERIMENT II.

THE ſame effect is obſerved when a piece of gilt leather S Y is made uſe of in the following manner. Let the end thereof S (fig. 11.) be in contact with the covering of the vial V, and when the filings are electrified, upon bringing the part t or x of the leather towards the wire w by means of an electric, an exploſion will enſue, and at the ſame time nearly a light or ſmall exploſion will be perceived in the little intervals of the broken leaf-ſilver which lie between t Y, or x Y, without the circuit, as well as in the intervals which lie between S t or S x within the circuit. And thoſe little exploſions will be more in number, and alſo more viſible, if a perſon takes hold of the leather at Y or x, and ſtill more ſo, the nearer the perſon's hand is to t or x.

SECTION

SECTION VII.

PROPOSITION XIII.

AN exploſion never happens but when the iſſuing electric matter is very much condenſed.

THIS appears from pointed metal bodies when electrified in dark places. For the electric matter, in paſſing from a pointed piece of metal, will be ſeen to iſſue from it in diverging rays; on bringing a non-electric body near it, that divergency leſſens; and in proportion as the body comes nearer, the divergency grows leſs and leſs; till at length the rays continuing to cloſe, and to recede more and more from their divergency, till they are brought to a kind of focus, an exploſion is made.

FROM the electric matter firſt approaching towards a paralleliſm, and afterwards converging to a kind of focus before the exploſion is made, the condenſation muſt be greateſt at the time of the exploſion.

IF the acute end of this piece of metal be an exceeding fine point, no ſenſible exploſion will inſue, even though it be approached exceeding near by the non-electric: becauſe the electric matter will now appear to paſs out nearly in a parallel direction, and more equally and faſt, forming a kind of column or cylinder, whoſe diameter is exceedingly ſmall and ſcarce perceivable. Therefore in ſuch circumſtances there cannot be any ſenſible exploſion, as there is no ſenſible convergency.

PROPOSITION XIV.

THE greateſt exploſion, in certain circumſtances, is from poliſhed ſurfaces of metal; and this exploſion is greater the larger the ſurfaces are, to a limited degree.

LET the point of a needle not electrified, be brought near another of the ſame kind which is electrified, and no exploſion will be perceived, even though the room be darkened. If inſtead of theſe very fine points you take other non-electric bodies which have points not ſo very fine, there will inſue a very ſmall exploſion; and if the non-electric bodies have obtuſe terminations, the exploſion will be more apparent. But the greateſt exploſion is from large poliſhed ſurfaces of metal brought towards each other in like manner, provided the corners or edges of theſe poliſhed ſurfaces are rounded off, or covered with wax.

THIS holds only to a limited degree; for on making uſe of very large ſurfaces, we have not found the exploſion to be increaſed in proportion.

PROPOSITION XV.

As it has been proved by experiments vii. and viii. ſect. iii. that the electric effects are always proportional to the denſity of the accumulated electric matter, and as thoſe effects are greateſt in the denſeſt bodies in their natural ſtate, thoſe bodies muſt be capable of receiving a greater quantity of electric matter, or in other words, of having the electric matter accumulated to a greater degree, than bodies which are rarer.

For when the vial V is filled with aſhes, ſaw-duſt, or cork, and electrified, the accumulation of electric matter will be leſs, than when the vial is filled with Venice turpentine, and leſs when filled with Venice turpentine, than with filings of iron, granulated lead, or quickſilver: ſuppoſing the electrifying power of the apparatus the ſame in each experiment, and the wheel turned an equal number of times. For the exploſion is greater from the filings, granulated lead, or quickſilver, leſs from the Venice turpentine, and leaſt of all from the aſhes, cork, or ſaw-duſt. So alſo the painful ſhock on a perſon's completing the circuit, is greater from the filings, granulated lead, or quickſilver, leſs from the Venice turpentine, and leaſt from the cork-aſhes or ſaw-duſt.

AGAIN, if different ſpheres of metal, ivory, wood, and cork, but of equal diameters, be ſuſpended on the bar and electrified, the largeſt exploſions will be from the metal ſpheres, and the leaſt from the wood and cork.

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PART II.

SECTION VIII.

IN this part we ſhall firſt give a ſhort account of the *æther* Sir *Iſaac Newton* has treated of, and endeavour to ſhew, that the ſubtile fluid which he calls *æther*, and that which we have been ſpeaking of, are one and the ſame. Then prove, that *light* is lodged in all bodies: and that, the denſer bodies are, the greater is the quantity of *light* contained in them. Laſtly, by the properties ariſing from the mutual action between *æther*, *light*, and *bodies*, we ſhall endeavour to ſolve ſome of the moſt remarkable effects of electricity: and attempt to confirm Sir *Iſaac's* doctrine of *gravitation*, *cohæſion*, &c.

Sir *Iſaac Newton* ſuppoſes that there is an exceedingly ſubtile and elaſtic fluid, which readily pervades all bodies, and is by its elaſtic force expanded throughout the univerſe: that its elaſtic force in proportion to its denſity is immenſely greater, than the elaſtic force of the air compared with its denſity: that the increment of the denſity of this fluid, in receding from a body, is as the quantity of matter in the body directly, and as the ſquare of the diſtance from the center of gravity inverſely.

To illuſtrate this increment of denſity, ſuppoſe the whole force of any globe to be contracted into a point A fig. 12. and a, b, two particles of *æther* placed at an exceeding ſmall diſtance from each other. Suppoſe c, d, two particles alſo of *æther*, placed at an equal diſtance from each other. Then the diminution of denſity is ſuch, that if a particle of matter B was placed between a, b, and another equal particle of matter C, between c, d; no regard being had to the quantity of matter in the particles B and C, the exceſs of force wherewith b preſſes the particle B more, than it is preſſed by a, is to the exceſs of force wherewith d preſſes the particle C more than it is preſſed by c, as the ſquare of the diſtance A C, is to the ſquare of the diſtance A B.

This fluid, which he calls *æther*, he ſuppoſes it to be denſeſt in empty ſpaces, and rareſt in the denſeſt bodies. And in bodies of different denſities, he ſuppoſes it to be rarer in denſer bodies; and denſer in rarer bodies.

He likewiſe ſuppoſes that *light* enters the compoſition of all bodies, and that by the mutual action of the *æther* without the bodies upon the *æther* and light within bodies, a very denſe graduated medium of *æther* is cauſed, which ſurrounds their ſurfaces to very ſmall diſtances; and may be of different denſity, according to the quantity of light in each body. This graduated medium of *æther*, he ſeems to think, is the cauſe of the reflection, refraction, and inflection of light (ſee *Opt.* page 241.) alſo of coheſion, fermentation, &c. For a more particular account of this, and how gravitation is cauſed, we refer to a *Diſſertation on the æther*, by Dr. *Bry. Robinſon.*

The electric matter has been proved in the firſt part of this treatiſe to be exceedingly ſubtile and elaſtic, and to be contained in all bodies we are acquainted with. And there is reaſon to think that it is denſeſt in ſpaces void of groſſer matter, as we ſhall endeavour to ſhew more fully hereafter from experiment and reaſon. Since therefore in theſe properties it ſtrongly reſembles the *æther*, we may look upon it as the *æther* joined with groſſer particles of matter propelled from bodies by the force and vigour of its action.

COROLLARY I.

FROM the *æther's* being denſeſt in the rareſt bodies, and rareſt in the denſeſt bodies, it follows, that, if a body be made rarer by any means whatſoever, the *æther* in that body muſt grow denſer. Becauſe the parts of the body are removed to a greater diſtance from one another. And conſequently the pores or vacuities in that body will be larger.

COROLLARY II.

AND if a body be made denſer by any means whatſoever, the *æther* in that body will grow rarer, becauſe the parts are brought nearer together: conſequently the pores or vacuities in that body will be ſmaller.

COROLLARY III.

FRICTION will cauſe bodies to rarefy as well as the heat of the ſun, or any other heat; and thoſe rarefied bodies will contract and grow denſer on diſcontinuing the friction, or on removing their rarefied parts from the friction.

COROLLARY IV.

HENCE it is evident, that as bodies grow rarer by heat, *æther* flows into them from other bodies; and that as they grow denſer by cold, *æther* flows out of them into other bodies. So that the denſity of the *æther* in any particular body, is as the mean denſity of all other bodies in proportion to the denſity of that body. And therefore the denſity of the *æther* in any particular body will be increaſed, when any other body or bodies are condenſed, or when that body is rarefied. And on the contrary, the denſity of the *æther* in any particular body will be leſſened when any other body or bodies are rarefied, or when that body is condenſed [a].

PROPOSITION XVI.

WHEN two bodies are rubbed againſt each other, the *æther* will flow in greater quantity into the rarefied parts of the bodies, than into thoſe parts of the ſame bodies which are not rarefied: and that in a different degree as the parts of the bodies are more or leſs rarefied. And upon the parts of the bodies growing denſer, the *æther* muſt paſs out of the bodies where it meets with the leaſt reſiſtance.

WE have ſhewn from ſeveral experiments which follow the viith propoſition, that different bodies obſtruct the paſſage of the electric matter with different degrees of ſtrength.

IF now it be true, what Sir *Iſaac Newton* ſeems to think (and what we hope we ſhall be able to confirm hereafter from experiments) that there actually ſurrounds all bodies, to very ſmall diſtances, a very denſe graduated atmoſphere

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[a] See Dr. *Robinſon's* Anſwer to a pamphlet intituled, *Remarks on Dr. Robinſon's Syſtem of Muſcular Motion.*

ſphere of *æther* of different degrees of denſity, ariſing from the different denſities of the bodies, and the different quantities of light contained in them, it will be eaſy to conceive how the *æther* may be retained within a body by the ſurrounding denſe atmoſphere of the *æther* obſtructing or reſiſting in ſome meaſure its *exit* out of the body: and how ſome bodies which have this atmoſphere denſeſt, retain the accumulated *æther* longer than others which have it leſs denſe. Such bodies are glaſs, amber, wax, reſin, glue, and other electrics: for they, when electrified, will continue to act upon light bodies much longer than iron, and other non-electrics, when electrified. And for the ſame reaſon, glaſs, amber, wax, and other electrics, muſt be leſs capable of receiving the *æther* by communication, than metals and other non-electrics.

From the ſame principle we may conceive how the *æther* gains admittance through the ſmall ſurrounding denſe atmoſphere of *æther*, into the body where it is to be accumulated.

For when the parts on the ſurface of the body G are rarified, that part of the denſe atmoſphere of *æther* which we ſuppoſe extended over the rarefied parts, muſt be rarefied alſo: and ſince that is the caſe, the obſtruction or reſiſtance given to the entrance of the *æther* into G, muſt thereby be leſſened. Conſequently if there be a flux of *æther* from C towards that part of G thus rarefied, the paſſage or entrance into G will thus be more eaſy.

LET us now inquire how a flux or flowing of the *æther* from the parts adjacent can be cauſed. And again, how it eſcapes into other bodies, and why friction only can produce theſe effects.

SUPPOSE the cuſhion C, which is to rub the cylinder G, to be one uniform denſe body, of a given magnitude. And ſuppoſe the *æther* in that body, before any part of the body is heated more than another, to be of an uniform denſity. Let the cuſhion C be placed, along with the cylinder G, on a body which has the denſeſt atmoſphere of *æther* ſurrounding it: for example, wax or glaſs, R, as in the experiment following the ivth propoſition. This being done, rarefy part of the ſurface C by rubbing it againſt G, and G will be rarefied alſo. The parts of both bodies being thus rarefied, the *æther* muſt grow denſer in thoſe rarefied parts than it was before by coroll. i. but the whole quantity of matter in the glaſs G is leſs than the whole quantity of matter in C, therefore (ſuppoſing no *æther* to flow from any body or place that lies without thoſe bodies G and C) the *æther* in thoſe parts of the bodies which are not rarefied, muſt flow into their rarefied parts, by coroll. iv. And if a quantity of *æther* proportional to the rarefaction of the bodies, paſſes into the rarefied parts, it is evident that a greater quantity of *æther* muſt flow from C than G, before the *æther* within them, or in the parts which are not rarefied, is attenuated or rarefied to an equal degree in each.

Now, though the *æther* be denſer in the rarefied parts of the bodies C and G, than it was before the friction, yet as the reſiſtance given to the exit of the *æther* at thoſe rarefied parts by the graduated atmoſphere, is leſſened, on account of the friction, the *æther* contained not only in thoſe rarefied parts, but in the other parts of the body, may, by the appoſition of a non-electric, paſs off more readily than it otherwiſe would have done, and the quantity of *æther* in the whole body may thereby be leſſened.

In this caſe we ſuppoſe the flux of the *æther* from the circumambient bodies is in a great meaſure prevented, and therefore as the expanſive force continually decreaſes, the iſſuing of the *æther* muſt alſo gradually leſſen, and in a ſhort time totally ceaſe.

This quantity cannot be leſſened beyond a certain degree, becauſe a certain quantity is requiſite to overcome, by its expanſive force, the reſiſtance given to its *exit*.

THIS is confirmed by experiment: for when the machine is ſet upon wax, we are not able to produce any more electric matter than a very ſmall quantity, though the friction be continued for any length of time. See experiment following propoſition iv.

ON adding more matter to C, the quantity of *æther* is increaſed, and conſequently a greater quantity muſt paſs off, than in the laſt experiment, before it arrives at the ſame degree of attenuation or rarefaction. This is alſo confirmed by experiment. See propoſition iv.

HENCE we may ſee the reaſon why, when ſo large a maſs of matter as the whole earth is added, it is not in our power to attenuate or rarefy the *æther* in it to any ſenſible degree: And why the electric effects in this laſt caſe are ſo much greater than in the preceding ones.

FOR the magnitude of the earth being immenſely greater than the magnitude of the bar, the *æther* muſt flow in as great a quantity from the earth into C and G, as it paſſes from them into the bar, even though the friction be continued ever ſo long.

THE firſt experiment in ſection ii. confirms this, as well as the experiment following the ivth propoſition: for when any non-electric communicates with C and the earth; or the wax R is taken away, there will be a continual iſſuing of the electric matter from the bar, and that for any length of time.

THE flowing of the *æther* muſt continue ſo long as the friction, becauſe the rarefied ſurface of the glaſs G removing every inſtant from the cuſhion, begins to cool and contract; ſo that the *æther* which flowed from C into the rarefied parts of the glaſs G muſt now paſs away where the reſiſtance to its *exit* is the leaſt: which will be found to be in the wires w w. For the oppoſite or inner ſide of the glaſs G, together with the air contained in the cylinder, reſiſt the *exit* of the *æther* more than the wires w w, in contact with the outer ſide, as it will be proved by experiments hereafter, And it cannot paſs back again towards C, becauſe the parts of the glaſs G at or near C, are more rarefied, than thoſe parts of G that are farther removed from C. Neither can the *æther* paſs into the air ſo copiouſly, as into the wires, it appearing from all the preceding experiments that air reſiſts its exit more than groſſer bodies.

FRICTION only then can cauſe theſe effects, as it gives the *æther* in the rarefied parts of the glaſs an opportunity to eſcape every inſtant into other adjacent bodies where the reſiſtance to its exit is the leaſt. For the parts of the glaſs that are moſt rarefied, are moved from the friction of the rubber every inſtant. And therefore ſuch bodies that reſiſt the paſſage of the *æther* leaſt, and happen to be neareſt G as it turns round, muſt receive moſt of the *æther* that iſſues from G.

COROLLARY I.

HENCE we may ſee the reaſon why upon turning the rarified parts of the glaſs from the wires w w, as in the experiment following propoſition i, the electric effects in the bar are conſiderably leſs. For in that experiment part of the electric matter paſſes into the frame of the machine.

COROLLARY II.

AND hence we may perceive the reaſon why equal effects can never be produced in the bar B B from the cuſhion and the glaſs, without friction; even though they are heated to any degree whatſoever, by the fire or the ſun. See experiment i. ſection ii.

COROLLARY III.

HENCE alſo we may underſtand how it is that the flowing of the *æther* gradually leſſens, and at laſt ceaſes on diſcontinuing the friction. And how the electric effects from the glaſs grow weaker as it cools and recovers its original ſtate.

COROLLARY IV.

HENCE likewiſe we ſee the reaſon why two thick electrics rubbed againſt each other can never produce ſo ſtrong effects as an electric and a non-electric body. And therefore why ſetting the machine on non-electric bodies, moiſtening the leather of the cuſhion (which when dry is in ſome degree an electric) and all other circumſtances to keep an open communication with the cuſhion C, are abſolutely neceſſary for producing the greateſt flux of the *æther*. This agrees alſo with the firſt corollary to propoſition iv. And again, why ſilk or hair lines, glaſs, amber, wax, reſin, pitch, glue, and all other electric bodies which obſtruct or reſiſt the exit or entrance of the *æther* more than metals or other non-electric bodies, are the only bodies abſolutely neceſſary to hang or ſet non-electric bodies upon, in order to ſee how far the *æther* is capable of being accumulated in any non-electric body in ſuch particular circumſtances. And why thoſe laſt mentioned bodies ſhould be always dry and free from duſt and dirt. All which things are agreeable to what we have advanced in the firſt ſection.

PRO-

PROPOSITION XVII.

WHEN the *æther* is put into ſuch a motion within a body as in the laſt propoſition, it will throw off, by the violence of its action, ſulphur, and other matter lodged on the ſurface or within the pores, where it is leſs intimately combined with, and united to the parts of that body.

FOR the electric matter, in paſſing out of bodies, is generally obſerved to be of a ſulphurous nature from its ſmell. And if a hand, or any other part of the body be held for ſome time in the ſtream of the electric matter as it iſſues, the hand, or that part which is oppoſed, will acquire the ſame kind of ſmell: nor will it preſently loſe that ſmell. The ſame effluvia will likewiſe whiten red roſes, as ſulphurous ſteams are known to do [a].

COROLLARY I.

HENCE the roſe and hand ſeem to be a kind of ſtrainers by which the more groſs ſulphurous and other particles are ſeparated from the more fine and ſubtile ones of *æther*.

COROLLARY II.

FROM this ſulphurous matter condenſed in the focus along with the *æther*, and fermenting with the nitrous acid floating in the air, it is probably that the ſudden blaſt or violent exploſion in electrical experiments is produced [a]: in like manner as Sir *Iſ. Newton* has obſerved that lightning, thunder, and fiery meteors are cauſed by ſulphurous ſteams fermenting with that acid; for, ſays he, the air abounds with acid vapours; as appears by the ruſting of iron and copper in it, the kindling of the fire by blowing, and the beating of the heart by means of reſpiration.

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[a] The whitening of red roſes, by placing them in the ſtream of the electric matter, was obſerved by Dr. *Bevis*.

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[a] That air is neceſſary for the production of theſe effects, appears from many experiments; for if two non-electric bodies be included in a glaſs receiver exhauſted of air, or to as great a degree as we are yet able, and one of thoſe bodies afterwards electrified, on their being moved near each other there will inſue no exploſion like that we perceive when the air is not exhauſted; but there will appear a faint light between the bodies, and this is only viſible when the experiment is made in a dark place. This faint light ſeems to require a certain quantity of air within the glaſs; for it is moſt viſible when the air is not rarefied to ſo great a degree as we are able.

That an acid in the air is requiſite to produce the greateſt exploſion, appears from the experiments made when the wind blows northerly or eaſterly. For the effects are then greateſt with reſpect to the exploſion. And it is generally admitted, that the air abounds more with acid when either of thoſe winds blow than when any other wind blows.

Again, when the air abounds with ſulphur, as in hot weather, and when there is thunder and lightning, the exploſion in electrical experiments is leaſt.

We will illuſtrate this matter farther by the following experiments.

A lighted candle will go out, and glowing coals ceaſe to ſhine in the air pump on drawing out the air: nay, red hot iron will ceaſe to ſhine in a ſhort time, upon exhauſting the receiver of air. Again, a candle will go out, glowing coals and red hot iron ceaſe to ſhine in a ſmall quantity of air ſo cloſely confined as to have no communication with the reſt of the atmoſphere. If two parts of a compound ſpirit of nitre (which is a ſtrong acid ſpirit) be poured on one part of oil of cloves, or carraway ſeeds, or of any ponderous oil of vegetable or animal ſubſtances, or oil of turpentine, thickened with a little balſam of ſulphur, the liquors grow ſo very hot in the mixing as preſently to ſend up a burning flame. If a drachm of the ſame compound ſpirit be poured upon half a drachm of oil of carraway ſeeds, even in *vacuo*, the mixture immediately makes a flaſh like gunpowder. And well rectified ſpirit of wine poured on the ſame compound ſpirit flaſhes. Common brimſtone and nitre powdered, mixed together, and kindled, will continue to burn under water, or in *vacuo*, as well as in the open air.

SECTION IX.

WHEN we hereafter ſpeak of electric matter, we would be underſtood to mean the *æther* put into ſuch a motion within a body, as to carry along with it ſulphur and other groſs matter. But when we ſpeak of the *æther*, we mean the ſame fluid, but not put into that degree of motion.

LIGHT is proved by Sir *Iſ. Newton* to conſiſt of particles of various ſizes: but the particles of *æther*, he ſays, are exceedingly ſmaller than thoſe of light.

PROPOSITION XVIII.

ÆTHER is more ſubtile than light.

FOR if *æther* and light are put into ſuch a motion, as to be propagated to immenſe diſtances in a ſhort ſpace of time, and the particles of one of them continue to move on with an equal, or rather with an accelerated motion through the moſt denſe bodies interpoſed (ſee experiment x. ſection iii.) whilſt the particles of the other are either abſorbed, or ſtopt by ſuch interpoſition, or reflected from their ſurfaces; it follows that thoſe particles which paſs through the interſtices of bodies, are more ſubtile than thoſe which do not paſs.

But *æther* has been proved to paſs through denſe bodies, which light will not paſs through, therefore *æther* is more ſubtile than light[a].

THE velocity of light is exceeding great, and though the particles conſtituting the different rays are of various ſizes, yet they all deſcribe equal ſpaces in the ſame time. To account for the propagation of light from the ſun to us, in ſo ſhort a time as ſeven or eight minutes, various have been the hypotheſes framed. All theſe Sir *Iſaac Newton* has endeavoured to ſhow, in queſtion xxviii. to be very erroneous, and from the force of reaſon joined to obſervation and experiments, ſubſtituted the *æther* we have ſo often mentioned, and this at a time when electricity was but little known.

PROPOSITION XIX.

DENSE bodies contain more light in their compoſitions than rare bodies, unctuous and ſulphurous ones excepted.

THIS appears from their emitting light more copiouſly when their parts are ſufficiently agitated,

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[a] It may be reaſonably objected, that this propoſition is by no means ſufficiently proved, ſince light will paſs through glaſs, amber, gums, &c. which the *æther* will not, or, however, from what has hitherto appeared. For an anſwer to this, we refer to the remainder of this treatiſe, and particularly propoſition xxvii. and xxx. where we undertake to ſhew that all bodies may be electrified.

tated, whether that agitation be made by friction, percuſſion, or putrefaction, or any other cauſe. For inſtance, denſe bodies which refract and reflect light moſt ſtrongly when expoſed in the ſummer ſun, acquire a greater heat by the action of the refracted or reflected light; and if the heat be increaſed till it be about four times hotter than boiling water, then ſuch denſe bodies will emit light ſo copiouſly as to ſhine.

PROPOSITION XX.

Such bodies as are unctuous and ſulphurous have more light in their compoſition than others of the like denſity.

The more copious the emiſſion of light is from bodies, when their parts are agitated, the greater is the quantity contained in them.

Now ſulphurous bodies, acted upon by the rays of light collected into a focus by a lens flame, burn more vehemently than others of the ſame denſity that have leſs ſulphur in them, or, in other words, emit more light; and muſt therefore have more light in their compoſitions.

Corollary.

Since all bodies refract, reflect, and inflect light by one and the ſame power, and their power of refraction is nearly as their denſities, their power of reflection and inflection muſt be in the ſame proportion.

THE quantity of light too in their compoſition is for the moſt part as their denſities. It ſeems to follow then, that the power in bodies to refract, reflect, and inflect the rays of light, is nearly proportional to the quantity of light contained in them.

PROPOSITION XXI.

THE inflective, refractive, or reflective power of a body extends itſelf but a very ſmall diſtance from the body.

FOR the rays of light in paſſing by bodies are not affected ſo as to be turned out of their rectilineal courſe, till they are very near the edges. *Vide Newt. Opt.* III. L. The cauſe of this power or medium, which ſurrounds all bodies, remains to be enquired into.

1. THE law eſtabliſhed between the *æther* and bodies, for making the *æther* the cauſe of moſt of the phænomena of nature, reſpects both the quantity of matter and the quantity of light contained in bodies.

2 THAT part of the law which reſpects only the quantity of matter, we have given before, which in other words amounts to this: The body and the *æther* lying next to it all round, repel one another with a force which

is meaſured by a rectangle under the quantity of matter in the body, and the denſity of the *æther* applied to the ſquare of the diſtance of the ſurface from the center of gravity of the body. If the body be a globe of an uniform denſity throughout, in which caſe the center of the globe will be its center of gravity, the *æther* will preſs on the globe by endeavouring to expand itſelf, and by that preſſure it will recede from the globe, and its denſity will continually increaſe, and the increment or increaſe of denſity at any diſtance, will be as the quantity of matter in the globe directly, and the ſquare of that diſtance from the center of the globe inverſely. If the globe be large, the ſphere of *æther* ſurrounding it, whoſe denſity thus increaſes, will be large; and the ſphere of *æther* will be ſmall if the globe be ſmall. The ſphere of *æther* ſurrounding the ſun, occaſioned by the action of that great body, extends much beyond Saturn, nay, beyond the diſtance of the remoteſt of the comets aphelium. The ſphere of *æther* ſurrounding the earth occaſioned by the action of the earth on this medium extends itſelf beyond the moon. Hence any body placed within a ſphere of *æther* belonging to the ſun, earth, or any other great globe will move towards it, the *æther* being denſer on the remoter ſide of each particle of the body than on its nearer ſide, with reſpect to the globe: if the globe be ſmall, the ſphere of *æther* ſurrounding it will be ſmall; and the increment of the denſity, which at the ſurface of a globe is as at its diameter and denſity taken together, may be ſo very ſmall as not to be able to produce any ſenſible motion in a ſmall particle placed within the ſphere of that ſmall globe. The increment of the denſity of the *æther* at the ſurface of a globe of a given denſity, being as the ſemi-diameter of the globe: and the ſemi-diameter of the earth being 3965 engliſh miles, or 251222400 inches, the increment of the denſity at the ſurface of the earth, and at the ſurface of a ſmall globe of the ſame denſity with the earth whoſe ſemi-diameter is 1 inch, will be 251222400 and 1 the ſpaces deſcribed in 1″ by a corpuſcle moved by theſe forces will be 193 inches and $\frac{1}{1301670}$ part of an inch. Hence the corpuſcle moved by the force of the little globe will be above 15 days in deſcribing 1 inch, and conſequently the force of gravity in the ſmall particles of matter is altogether inſufficient for producing the violent motions thoſe particles have in fermentation.

THAT part of the law which reſpects light reaches but to a very ſmall diſtance from the ſurface of bodies, and ſuch as is mentioned in the laſt propoſition. The light which enters the compoſition of all bodies by powerfully repelling the adjoining *æther*, and thereby increaſing its denſity to a very ſmall diſtance (ſuppoſe to the eight hundredth part of an inch) from the ſurface of bodies, conſtitutes this force. That light and *æther* act with immenſe force on one another, appears from the rays of light (which move above 158000 Engliſh miles in a ſecond of time) being turned out of their rectilineal courſe by the *æther* at the ſurface of bodies: for it requires an immenſe force to turn a body moving with ſo great a velocity out of a rectilineal courſe. Light and *æther* repel one another very ſtrongly, and hence it is that light adhering to the ſurface of bodies, repels the adjoining *æther* with great force, and thereby cauſes a great and quick increaſe of its denſity to a ſmall diſtance from the ſurface, ſuch as is repreſented by fig. 13. from the particle or body A to b; at the end of this diſtance from the ſurface, that is, at b, the *æther* is denſeſt: and much denſer than it would be from the quantity of matter in the body. The force of light terminating at this diſtance, the *æther* condenſed by that force will afterwards relax and rarify to ſome certain diſtance, ſuppoſe at c, and beyond that diſtance it will go on to be condenſed by the ſole action of the quantity of matter in the body to d, and beyond. The condenſation and rarification of the *æther* at the ſurfaces of bodies conſtitute two forces, an impulſive force, which is from b to the body A, and a repulſive force, which is from b to c: thoſe forces act very powerfully on minute particles which come within the limits of their action. Hence theſe forces are ſtrongeſt in bodies which contain moſt light in their compoſition with reſpect to their denſities, that is, they are ſtrongeſt in ſulphurous and unctuous bodies.

The narrow limits of the two forces conſtituted by light prevent them from affecting bodies of any ſenſible magnitude, for bodies muſt be ſo ſmall as to fall within theſe limits before they can be moved by theſe forces. A body leſs than the eight hundredth part of an inch in diameter, ſuppoſe a (fig. 14,) placed between the denſeſt part of the *æther* b and the ſurface of the body x, will move towards the body x by receding from the denſer part of the *æther* towards the rarer. The ſame ſmall body a, placed beyond the denſeſt part of the *æther* b of the body x, will move from the body x by receding from the denſer part of the *æther* towards the rarer. So that when the denſeſt part of the *æther* b, cauſed by the ſuperficial light of a body, falls without a ſmall particle a, (fig. 14) that particle a will move towards the body x: and if x be equal to a, they will move equally faſt towards each other: and they will move from each other if the denſeſt part of the *æther* b, c, lie between the particles x and a, (fig. 15) or in other words if the particles are placed any where within the bounds of their repulſive forces.

The rays of light ſeem to be reflected regularly by virtue of this medium evenly diffuſed all over the ſurface of a poliſhed body. " Sir *Iſaac Newton* ſays, " were the rays of light " reflected by impinging on the ſolid parts of " bodies, their reflections from poliſhed ſurfaces could not be ſo regular as they are. For " in poliſhing glaſs with ſand, putty, or tripoly, it is not to be imagined that thoſe ſubſtances can by grating and fretting the glaſs " bring all its leaſt particles to an accurate poliſh; ſo that all their ſurfaces ſhall be truly " plain, or truly ſpherical, and look all the " ſame way, ſo as together to compoſe one " even ſurface. The ſmaller the particles of " thoſe ſubſtances, are the ſmaller will be the " ſcratches by which they continually fret and " wear away the glaſs until it be poliſhed, but " be they ever ſo ſmall they can wear away " the glaſs no otherwiſe than by grating and " ſcratching it, and breaking the protuber-

" ances, and therefore poliſh it no otherwiſe " than by bringing its roughneſs to a very fine " grain, ſo that the ſcratches and frettings of " the ſurface become too ſmall to be viſible. " And therefore if light were reflected by im" pinging upon the ſolid parts of the glaſs, it " would be ſcattered as much by the moſt po" liſhed glaſs as by the rougheſt." For theſe rays only which fall upon the tops and bottoms of the protuberances and cavities would be reflected according to the general direction of the whole ſurface of the body: thoſe which fall upon the oblique ſides of thoſe protuberances would be reflected in a different angle.

THAT medium which we have ſhewn to ſurround all bodies to very ſmall diſtances, and which is ſuppoſed by Sir *Iſaac Newton* to be the cauſe of the reflection, refraction, and inflection of light, we ſhall call by the different names of the reflective refractive, or inflective medium, or in one word by *atmoſphærula*, as will beſt ſuit our preſent purpoſe.

SECTION X.

PROPOSITION XXII.

THE *atmoſphærula* ſurrounding any body prevents the electric matter, when accumulated within that body, from iſſuing ſo faſt as it otherwiſe would, if there was no *atmoſphærula* ſurrounding it.

FOR the electric matter, its expanſive force being equal at every point of the ſurface of a body electrified, ought to expand itſelf and be propagated equally from all parts of the body into the air; and that as faſt as it enters into the body: ſo that there could be no accumulation of the electric matter, (See Sect. iii, Experim. 7.)

BUT it is found that a globe of metal will continue electrified for ſome time; and that if a pointed piece of metal be fixed to it, the globe will not continue ſo long electrified; and the electric matter will iſſue moſt from the point. Whence it appears that there is ſomething acting at the ſurfaces of bodies which retards the exit of the electric matter: and that more or leſs according to the circumſtances which attend

tend the experiment. What this cauſe is, we ſhall now inquire.

THE preſſure of the air upon the ſurfaces of bodies cannot be the cauſe; for the preſſure of the air on any given part of the ſurface of a pointed body muſt be equal to the preſſure on an equal given part of the ſurface of any other body which is not pointed: and the preſſure being equal in both theſe caſes, the electric matter ought to meet with an equal reſiſtance from the air. Yet notwithſtanding we find that the electric matter paſſes off ſooner from pointed bodies than from bodies that are not pointed: and that the diſſipation is performed in the ſhorteſt time when the points are the fineſt. Beſides, this holds equally true *in vacuo:* and therefore thoſe effects may ariſe from the *atmoſphærula* being rarer at a point, than at the ſurface of a body.

IF this ſuppoſition be true, it follows, that the rarer the *atmoſphærula* is, the leſs will be the reſtance to the exit of the electric matter. Now the finer points are, the more copious is the iſſuing of the electric matter from them; therefore the propoſition is true.

PROPO-

PROPOSITION XXIII.

The electric matter upon its iſſuing ſuddenly through a denſer *atmoſphærula* produces a greater effect than when it iſſues through a rarer.

To any part of the wire w (fig. 16.) fix a very thin piece of hard wax, glue, *Muſcovy* glaſs, or common glaſs G in the middle, or which will anſwer better, a piece of gilt leather three or four inches in diameter; then when the vial V is electrified, bring the diſſipator D towards the middle of the affixed body G, and the exploſion will be much louder than it would be from any part of the wire w, ſuppoſing the vial electrified to the ſame degree.

N.B. The leather muſt be varniſhed on the gilt ſide, and the edges of it covered with ſealing wax.

In this experiment the action of the electric matter is ſo ſtrong as to make a hole through the leather, and to force quite away the varniſh and ſilver, ſo as to leave the leather for ſome little ſpace round the hole quite uncovered. It is remarkable that the ſpace ſtript of the varniſh is greater than the ſpace ſtript of the ſilver.

If the wax, or very thin glaſs be made uſe of in the above experiment, the violence of the action of the electric matter will break it.

PROPOSITION XXIV.

In two or more circuits made at the ſame time, with the ſame vial, but with different bodies, the electric effect, ſuppoſing the filings in the vial ſtrongly electrified, will be in that circuit only where the electric matter will meet with the leaſt reſiſtance.

Proof by Experiments.

Experiment I.

To the loop x (fig. 17.) on the covering of the vial V, faſten one end of a wire C of any length, ten, a hundred, or a thouſand yards, for it appears to be the ſame thing in the event of this experiment, and when the vial is electrified as uſual, let the perſon P, who makes the experiment take hold of the vial V or the wire C at x, in one hand, and with the other hand H, laying hold of the other end of the wire c, bring that end of c towards the wire w, which is in the neck of the vial. By this means there will be two circuits made, as may be eaſily ſeen by the figure, the one with the wire and vial VCHW: and the other by the Perſon and vial VPHW. In ſuch circumſtances, the perſon will not feel the electric effect, or in other words, receive a convulſive ſhock, as the reſiſtance ariſing from the *atmoſphærulæ* is leſs on the ſurface of the wire C, than in the perſon. This is manifeſt from reaſon as well as experiment; for the parts of the wire C are ſuppoſed to be incontact from end to end, ſo that there can be only the reſiſtance ariſing from two *atmoſphærulæ* to be overcome, namely, that at each end. Whereas in the perſon there are different kinds of matter diſtinct from one another, namely, the fleſhy, bony, and nervous parts, beſides the blood and other fluids, which have their different *atmoſphærulæ*. But as it may ſeem difficult to conceive how bodies included within, or ſurrounded by other bodies in like manner as the nervous, fleſhy, and other parts of animal are, ſhould have their different *atmoſphærulæ* ſurrounding them, we ſhall ſet down an experiment that will ſerve to illuſtrate this matter.

EXPERIMENT II.

POUR an ounce or two of well diſſolved Venice turpentine into a thin glaſs cup, and afterwards pour two or three drops of milk, which has had the cream taken off, into the turpentine, in one part, and two or three drops into another part of the ſame cup, ſo that there may be two ſeparate quantities, or drops of milk in the turpentine; then turn the cup different ways, till the drops are brought as near together as you are able; for they will not mix till a conſiderable time after; then ſhake the cup, or let one drop preſs upon the other: and you will perceive an actual diſtance, though very ſmall, between them: and the drops will be convex and concave to one another, and have their edges turned up like lips. Shake them again, and you will ſtill find them to keep the ſame diſtance from one another, and retain ſomething of the ſame figures. If the turpentine be not ſhaked for about fifteen or twenty minutes, the two drops will come together ſo as to make but one.

QUERY. If the *atmoſphærula* ſurrounding thoſe drops of milk in the Venice turpentine be not the cauſe of this phænomenon, how comes it that the drops ſhould keep at a diſtance from one another and retain thoſe ſingular forms, even though they lye upon one another?

Now, according to this reaſoning, when the reſiſtance ariſing from the *atmoſphærulæ* in the perſon is leſs than in the other circuit, the electric effect ought to be felt in the perſon.

AND that this is the caſe will appear from the following experiment.

EXPERIMENT III.

LET one end of a clean unruſted chain (for example, ſuch a one as is commonly uſed for a jack) and of the ſame length with the wire c, laying looſe or unſtretched, be fixed to the vial at x, and the other end be brought round by the perſon to the wire w, as the wire c was before in the firſt experiment, propoſition xxiv. And the electric effect will not be in the chain but in the perſon, and to much the ſame degree as if no chain was made uſe of.

IN this laſt experiment, we conſider each link of the chain as having two ſeparate *atmoſphærulæ*; for if any thing ſhould paſs or be propagated through each link, it muſt paſs or be propagated through two *atmoſphærulæ* in each link: one as it enters, the other as it paſſes out; and upon ſuppoſition that the ſum of theſe *atmoſphærulæ*, and the reſiſtance ariſing from them added together, exceed the ſum of the *atmoſphærulæ*, and the reſiſtance ariſing from them in the perſon, the electric effect muſt be in the perſon, or where the reſiſtance is leaſt.

EXPERIMENT IV.

AGAIN, ſhorten the chain, and thereby leſſen the number of *atmoſphærulæ*, till ſuch time as the reſiſtance ariſing from the *atmoſphærulæ* in the perſon added together, exceed the reſiſtance ariſing from the *atmoſphærulæ* of the chain added together, and the perſon in theſe circumſtances will not be affected. Nor indeed will the perſon be affected when a chain of any length is made uſe of, provided it be ſtretched tight, ſo that the links may be nearer contact with each other.

COROLLARY.

THEREFORE different preſſures of the links againſt one another, whether it be cauſed by the weight of the chain, or by pulling it, will produce very different effects.

EXPERIMENT V.

THOUGH the electric effect be perceived in the perſon when there are two circuits performed, and the chain of a conſiderable length, and unſtretched: Yet if one circuit only be performed, and that with a chain unſtretched, the electric effect will be in the chain: as appears by the great exploſion, and the many ſmall ones between the links from end to end, which may be ſeen when there is but little light in the room. Theſe ſmall exploſions do not appear between the links in the other experiments.

EXPERIMENT VI.

AGAIN, if the unſtretched chain and a wire of an equal length make up the circuit at the ſame time, in the manner we have deſcribed above, the great exploſion will enſue, but none of the ſmall ones will be ſeen between the links of the chain.

From this laſt experiment we conclude, that the effect was along the wire in which was the leaſt reſiſtance, or the feweſt *atmoſphærulæ*.

If the reſiſtance ſhould be the ſame in all the circuits, whether there are two or more, it is eaſy to conceive, they will all be affected alike.

We have an experiment of this kind[a]. It is performed in the following manner.

Experiment VII.

Let the vial V (fig. 18.) be electrified, and placed upon a metal plate P, and let ſeveral perſons, three, four, five, ſix, or more, each of them take hold of the plate with one hand, and of a bar of iron d d, with the other: then let them move either the end or the middle of the bar d d towards the wire w, which paſſes into the vial, and they will every one be affected alike with a painful convulſive ſhock. Let them change places, and let the vial be electrified again, and the effect will be the ſame.

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[a] This experiment was communicated to me by Mr. *G. Graham.*

SECTION

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SECTION XI.

PROPOSITION XXV.

AS all groſs bodies have their *atmoſphærulæ* ſurrounding them, ſo it is probable the particles of air, which are heterogenious (or a collection of many kinds of bodies) have *atmoſphærulæ* ſimilar to the ſame kind of bodies, which are groſſer and larger.

For all bodies, whether ſolid or fluid, have their *atmoſphærulæ* by the viith, viiith, and ixth ſections, which *atmoſphærulæ* will be (excepting ſuch bodies as abound with unctuous particles) nearly proportional to their denſities, by propoſition xviii. ſection ix. So that if a ſolid or fluid be divided or ſeparated into any number of parts, each part having light in its compoſition, may, by the action of that light upon the *æther* without, have an *atmoſphærula* conſtituted. All bodies likewiſe, whether ſolid or fluid, may have their parts ſeparated from one another by the action of heat. When the parts of groſs bodies are ſeparated by heat, fermentation, or otherwiſe, and placed without the reach of each other's attraction, then the particles recede from one another, and may conſtitute air. When the particles of any body do not cohere ſtrongly, and ſuch is the caſe with fluids, a ſmall heat is ſufficient to ſeparate their parts and turn them into vapours. Groſs bodies are with the greateſt difficulty brought together, and upon contact they cohere moſt ſtrongly. The particles of permanent air ariſing from ſuch groſs bodies by fermentation recede from one another with the greateſt force. And becauſe the particles of permanent air are groſſer and ariſe from denſer ſubſtances than thoſe of vapours, thence it is that true air is more ponderous than vapour, and that a moiſt atmoſphere is lighter than a dry one, quantity for quantity. See *Newt. Opt.* p. 372.

PROPOSITION XXVI.

A SUFFICIENT number of ſuch laſt-mentioned particles, when placed in ſuch a medium as the *æther*, may conſtitute an electric fluid ſomewhat ſimilar to the atmoſphere of our earth.

SUPPOSE any number of groſs particles of different ſpecific denſities, for example, five orders, or degrees: and the firſt order of the leaſt denſity, the ſecond more denſe, the third denſer, the fourth denſer than the third; and the fifth denſeſt. Now ſuppoſe thoſe particles at a given diſtance from the earth to be thrown confuſedly into ſuch a medium as the *æther* acting by the ſame law that gravity acts: it is evident that the denſeſt particles will fall and be neareſt the earth; but thoſe particles having *atmoſphærulæ* much ſtronger than the force of gravity, will be kept from being in cloſe contact with the ſurface of the earth. The fifth order then will be neareſt the ſurface, and ſuppoſing thoſe to cover a given area thereof, the fourth, as being next in denſity, will preſs forward, and reſt upon the *atmoſphærula* of the fifth: the third will preſs upon the fourth as the fourth did upon the fifth: the ſecond, as being ſtill lighter, will reſt upon the third, and the firſt upon the ſecond. All theſe will form parallel plains (if the particles in each order are of equal denſities) of an uniform denſity according to the order in which it ranks: the groſſeſt and denſeſt particles, as obſerved above, being next the earth, whilſt the lighteſt will be removed to the greateſt diſtance from it. And as the ſize of the particles of each order muſt be ſuppoſed very minute, and conſequently their *atmoſphærulæ* nearer to an uniformity than if they were ſtill larger, they will be very eaſily moved among themſelves on the leaſt impulſe, and herein they come under the definition of fluids. Suppoſing then ſome particles of the firſt order to be intermixed with others of the fifth, according to the laws of hydroſtatics they muſt aſcend, as being ſpecifically lighter than thoſe of the fifth, fourth, third, or even of the ſecond order, and acquire ſo much motion as the acceſs or defect of gravity is able to produce. Again, theſe particles being very minute may be looked upon as equal in their denſities and diameters. Now as the denſity of air is found to be nearly equal, if not accurately ſo, to the force compreſſing it, the elaſticity thereof will be in the ſame proportion, the centrifugal forces of the adjoining particles are reciprocally proportional to the diſtance of their centers (an elaſtic fluid, the denſity of which is as the compreſſion, being compoſed of ſuch particles, by propoſition xxiii. lib. ii. *Newt. Principia*) the particles of *æther* therefore, lying in and between the particles of air, will be ſubject to the like laws upon compreſſion, and conſequently a ſufficient number of the abovementioned particles placed in ſuch a medium may conſtitute a fluid ſimilar to the air in our atmoſphere.

PROPOSITION XXVII.

If into a veſſel whoſe *atmoſphærula* is very great (for example glaſs) be put any kind of matter, and that be afterwards electrified, the reſiſtance the electric matter will meet with in paſſing out on compleating the circuit, ſeems to be as the thickneſs of the glaſs, the quantity of non-electric contact with the glaſs, and the ſum of their ſeveral *atmoſphærulæ*; to wit, of the diſſipator, the veſſel itſelf, and the matter contained within it.

By the ſeventh propoſition the electric matter will paſs through a glaſs that is thin, but not through one that is thick[a]. If the glaſs be very thin, the air alone contained within the glaſs may be electrified, and a convulſive ſhock will inſue upon a perſon's completing the circuit. But this effect from electrifying air will not happen if the glaſs be thick; nay, though it be only of ſuch a thickneſs as that when filled with filings of iron, it would produce the electric ſhock. It is plain then, that the thickneſs of the glaſs is one circumſtance always to be regarded. The quantity of non-electric contact, both on the inſide and outſide of the vial, is another circumſtance to be regarded by propoſition ix. That bodies are ſurrounded by an *atmoſphærula* which obſtructs the exit of the electric matter, with different degrees of ſtrength, according to the different denſity of the *atmoſphærula*,

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[a] To make this experiment, nothing more is required than to take a very thin vial which is dry, and put a cork into the neck thereof, through which cork puſh the wire W into the vial, and electrify the air within it in like manner as if it was filled with filings, quickſilver, or water.

phærula, appears from propoſition xxi. The *atmoſphærulæ* of the diſſipator may be increaſed ſo as to be more in number by propoſition xxiii. and made denſer or rarer at pleaſure, by interpoſing ſuch bodies as reſiſt the exit or entrance of the electric matter more or leſs. But ſuppoſing the diſſipator in theſe experiments to be one ſingle piece of iron, there will then be only two *atmoſphærulæ* to be overcome, together with thoſe ariſing from the wire w, and the covering of the vial. Therefore the ſum of thoſe reſiſting powers ariſing from their *atmoſphærulæ* are given. And in reſpect to the latter part of the propoſition, ſince the refractive power of bodies is nearly proportional to their denſities, and the refractive power of air in proportion to its denſity is near that of glaſs, notwithſtanding its rarity: if you take away the air, the reſiſtance which the electric matter will meet with in paſſing through the glaſs towards the diſſipator will be leſſened; becauſe in this caſe it will only meet with the reſiſtance ariſing from the internal and external *atmoſphærula* of the glaſs. But on the other hand when air is included within the ſame veſſel, ſince every particle of air has an *atmoſphærula*, the reſiſtance ariſing from the *atmoſphærulæ* of air muſt be added to the reſiſtance ariſing from the *atmoſphærulæ* of the glaſs. And therefore the reſiſtance given to the paſſage of the electric matter will be greater or leſs, as a greater or leſs quantity of air is included in the veſſel. This is confirmed by making the experiment.

LASTLY, the electric matter will paſs thro' a thicker glaſs filled with filings of iron, ſo as to give the electric ſhock, when it will not paſs through the ſame glaſs filled with air. Becauſe the reſiſtance ariſing from the *atmoſphærulæ* of the filings is leſs than the reſiſtance ariſing from the *atmoſphærulæ* of the particles of the air, as the particles of the filings are larger than the particles of the air: and on that account there are fewer *atmoſphærulæ* to reſiſt its paſſage; therefore the propoſition is true.

COROLLARY I.

HENCE if the vial be very thick there will be little or no accumulation, by propoſition vii. and conſequently no exploſion or convulſive ſhock on a perſon's performing the circuit with his hands, prop. x. experim. 12.

COROLLARY II.

WHEN the filings of iron in the vial are electrified, upon compleating the circuit three or four times one after another ſucceſſively, without electrifying afreſh, there will be but one large exploſion, and ſometimes will follow two or three very ſmall ones, after which the whole quantity of electric matter will appear to be diſſipated. If inſtead of iron filings the vial be filled with water, there will iſſue a greater number of exploſions. But the firſt exploſion from the water will be fainter than the firſt from the filings; and the ſecond and third exploſions louder than the ſecond or third from the filings: or in other words, the exploſions from the water approach nearer in uniformity to one another, both as to loudneſs and degree of light, than thoſe from the filings. But when the included air only is electrified, the number of the exploſions will be increaſed further, and their degrees of loudneſs and light will be ſtill leſs than in the laſt caſe: ſo likewiſe they will be more alike to one another as to loudneſs and degree of light.

QUERY, Do not theſe phænomena ſeem to be owing to the different *atmoſphærulæ* ſurrounding the particles of water and air, which by their preſſing between occaſion a greater reſiſtance, and thereby prevent the immediate and total diſſipation of the electric matter? For take away the air, and accumulate the electric matter in the vial by the wire w as before, upon compleating the circuit the whole accumulated quantity will appear to be diſſipated and loſt in one ſingle exploſion, which ſeems to be a ſtrong argument for the truth of what we have advanced. And when a body loſes any part of its original quantity of electric matter, as in propoſition v. may not the electric matter, by reaſon of the reſiſtance ariſing from the *atmoſphærulæ* of the particles of the air be one, if not the only, cauſe why the electric matter is not ſupplied afreſh from the air ſo readily, though more of it be contained therein than in the body? And for the ſame reaſon muſt it not be retained in the body?

SECTION XII.

PROPOSITION XXVIII.

FROM the different denſity of the *atmoſphærulæ* ſurrounding bodies, it is that ſome bodies are electric and others non-electric; regard being always had to the texture of the bodies. Such bodies as have the denſeſt *atmoſphærulæ* ſuppoſing them not fluid, moiſt, or ſoft, are called electrics; and thoſe which have the rareſt *atmoſphærulæ*, non-electrics.

THE truth of this propoſition ſeems evident from what has been ſaid before: for it has been proved that the electric matter paſſes into or out of thoſe bodies moſt readily, where the reſiſtance given to its exit or entrance is the leaſt; and the reſiſtance given to the exit or entrance of the electric matter has been ſhewn to ariſe from the *atmoſphærulæ* which ſurround bodies by ſection x. and to be in proportion to their different degrees of denſity. Thoſe bodies therefore whoſe *atmoſphærulæ* are the denſeſt (and ſuch are all electrics by propoſition xvi.) have not the electric matter communicated to or accumulated in them to any great degree without friction: whereas thoſe bodies whoſe *atmoſphærulæ* are rare (and ſuch are called non-electrics) will ſuffer the electric matter to paſs readily into, and be accumulated in them, and that to a high degree by communication only [a].

COROLLARY.

HENCE it appears that the reſiſtance given to the electric matter does not abſolutely ariſe from the nature and quality of the internal and conſtituent parts of bodies, but chiefly from the *atmoſphærulæ* on their ſurfaces. This will appear yet more fully hereafter.

PROPOSITION XXIX.

ANY fluid included in a veſſel may be electrified, though the *atmoſphærulæ* of many fluids are much denſer than that of common glaſs, as may be gathered from their refractive powers being much greater than the refractive power of common glaſs. This is the caſe with oil of olive, linſeed oil, and ſpirit of turpentine.

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[a] It may be objected that this propoſition is not ſufficiently proved: for if the *atmoſphærulæ* are proportional to the denſities of bodies, gold, as it is the denſeſt body, ought to be a ſtrong electric, whereas experience maniſeſts the contrary? In anſwer to this, ſee propoſition xxx.

THAT all fluids are non-electrics is evident from their being readily electrified, as any one may be convinced by putting the fluid into a veſſel, ſetting the ſame on wax, and letting a wire or any other non-electric touch the bar and the fluid in the veſſel. For upon turning the wheel, the like phænomena may be produced from the fluid, as was done from the bar in the firſt experiment, ſection ii.

BUT that a fluid whoſe *atmoſphærula* is ſo very denſe ſhould be capable of being electrified at all, may ſeem difficult to account for conſiſtent with what is before advanced; to wit, that bodies are rendered electrics by the great denſity of their *atmoſphærulæ*; together with a certain texture of the body. For ſome may aſk, whence it is that linſeed oil ſhould be a non-electric, and glaſs an electric, when the *atmoſphærula* of the former ſeems to be much denſer than that of the latter? To which we anſwer, that from all the experiments we have yet made of bodies being electric, in proportion to the denſity of the *atmoſphærulæ*, this law, which holds true in all ſolid bodies, does not obtain in fluids:

one reaſon of which at leaſt may be as follows. That an alteration on the ſurface of fluid bodies may be cauſed by the action of the electric matter: ſo that the *atmoſphærula* may be rendered rarer, or the reſiſtance to the entrance or exit of the electric matter made leſs; when it may not be the caſe if the body be ſolid, it being the property of fluids that their parts ſhoul at yield to any force impreſſed upon them, and by yielding, to be eaſily moved among themſelves.

N. B. THE blaſt reſembling wind ſeems to ariſe from the particles of air being put into a violent rapid motion by the iſſuing of the electric matter, which muſt neceſſarily be greateſt at points, edges, or angular terminations, as the electric matter flows through them moſt readily. That the air is put into ſuch a motion appears from the two following experiments.

EXPERIMENT I.

FIG. 19. repreſents a cork ſtuck upon a needle, with ſmall bits of paper let into its ſides, which ſerve for fanes; when the other end of the needle is ſuſpended by the magnetic virtue of a load-ſtone or piece of ſteel, it may be eaſily turned round with a very ſmall force. If the cork thus ſuſpended be brought near the point of any body which is electrified, it will be turned round very quick, and continue to do ſo whilſt the body continues to be electrified.

EXPERIMENT II.

THE ſame cork ſuſpended by the magnetic virtue as in the other experiment, when placed in a large receiver exhauſted of air, will not have the leaſt rotatory motion, although it be as near the ſame electrified point as before. But immediately upon ſuffering a ſmall quantity of air to enter the receiver, the cork will turn round, and continue to do ſo if the point be continually electrified.

PROPOSITION XXX.

ELECTRIC bodies may be rendered non-electric by heat.

Proof by Experiments.

THIS is the caſe with wax, pitch, roſin, or glue, when melted. For if in a large iron ladle any of thoſe bodies be thoroughly melted, and the ladle be afterwards ſuſpended with a ſilk line, or laid upon wax, there being a wire, or ſome non-electric body ſo placed, as to conduct the electric matter from the iron bar to the center of the ſurface of the melted matter, the ladle will be electrified; and an exploſion may be produced both from the ladle and the melted matter. But as they grow cold they will be leſs and leſs electrified: And when they are quite cold, there will iſſue no exploſion from either of them; nor will light bodies be moved towards them, as before they would.

Experiment II.

To a glaſs cylinder G (fig. 20.) open at both ends, eight inches long, and about three wide, I fixed at one end a metal plate m, with a ſtrong cement, of ſuch a nature as that the cement would require a greater heat to melt it, than is requiſite to melt either roſin or bees-wax. This I did to prevent ſome melted roſin, which I intended to pour in ſoon after, from running out of the bottom of the glaſs. Into this cylinder I let drop a ſmall piece of metal red hot, in order to keep the melted roſin when poured into the cylinder G from chilling too ſoon at the bottom. I ſet the metal plate, and cylinder thus prepared on the earth, and then filled the cylinder with boiling roſin (the ſurface of which communicated with the bar by means of the wire w) upon turning the wheel and bringing my hand towards the bar no exploſion enſued; though the bar was ſufficiently ſupplied with electric matter, as appeared from the exploſions when the wire was taken away. After ſtaying ſome time till the heat of the roſin was ſomewhat abated, the electric matter began to appear in ſmall exploſions on my approaching the bar, and as the heat ſtill decreaſed the exploſions grew ſtronger; till at length when the roſin was become quite ſtiff, the exploſions were as ſtrong as when the wire and glaſs were removed from the bar.

EXPERIMENT III.

INTO a coated vial of the ſame kind with that we have all along made uſe of, I poured ſome melted roſin (the vial being firſt made gradually hot to prevent it from breaking) till it was nearly filled, and put the wire w into it, then taking hold of the covering of the vial, I electrified the melted roſin that was within the vial, and on compleating the circuit, there iſſued a large exploſion; attended with a convulſive ſhock. As the heat decreaſed, the exploſion and ſhock became gradually leſs; till at laſt I was not able to cauſe any exploſion or ſhock by compleating the circuit.

EXPERIMENT IV.

GLASS, when heated much, is alſo a non-electric. This I tried at a glaſs-houſe by various experiments in the following manner.

HAVING fixed the electric apparatus M, and ordered the wheel thereof to be continually turned, that the electric matter might be continually ſupplied to the bar, I deſired one of the workmen to take out of the furnace as much of the hotteſt melted glaſs with an inſtrument they call a blowing-iron or pipe, as would cover the end thereof four or five inches thick, and to deliver it to another workman who ſtood upon a board ſupported by bottles. This laſt perſon was continually electrified by means of a wire which paſſed from the iron bar to him, and that in a very ſtrong degree, before he took hold of the blowing-iron with the hot glaſs at the end of it. On my approach towards the thickeſt part of the melted glaſs, with a bar of iron, an exploſion enſued, and that as often as I approached it. But the exploſion became weaker as the glaſs cooled, till at length no exploſion could be produced.

EXPERIMENT V.

I NOW laid the bar of iron in my hand upon the thickeſt part of a freſh quantity of melted glaſs, and approaching with my other hand the blowing-iron which was held by the perſon ſtanding on bottles, no exploſion enſued: but as the glaſs cooled, the electric matter began to appear in exploſions from the blowing-iron; which exploſions increaſed in loudneſs and light as the glaſs grew colder.

EXPERIMENT VI.

A PERSON who was continually electrified from the bar took hold of the blowing-iron, on which was gathered a freſh quantity of melted glaſs. Immediately to this I applied a piece of iron, and drew out from the glaſs a ſlender thread of above four feet in length. During all the time of drawing it out, no ſigns appeared of there being any electric matter in the perſon. But ſoon after (for the thread of glaſs was preſently cooled) the perſon was ſtrongly electrified.

EXPERIMENT VII.

I ORDERED another piece of melted glaſs to be gathered, nearly equal in quantity to the former, and having electrified the filings in the vial to the greateſt degree, I placed the melted glaſs (which was better than four inches thick round the end of the blowing-iron) ſo as to make up a part of the diſſipator. (See fig. 21.) Upon compleating the circuit, an exploſion enſued, and near the whole quantity of electric matter was diſſipated; in like manner as when the circuit is compleated with a bar of iron, or a wire only. But theſe effects were not produced when the glaſs became colder; even though the glaſs was not a quarter of an inch in thickneſs.

EXPERIMENT VIII.

I REPEATED this laſt experiment, but did not electrify the filings in the vial ſo ſtrongly, and inſtead of compleating the circuit with metal, I did it with my hands, when I felt the uſual painful ſenſation and convulſive ſhock in my arms and acroſs my breaſt.

EXPERIMENT IX.

I TRIED the ſame experiments with a large piece of heated amber, inſtead of melted glaſs, and found the effects to be much the ſame as in the foregoing experiments.

UPON the whole of theſe experiments, doth it not ſeem, that, was ſpirit of turpentine, or lintſeed oil, and many other fluids, to become hard and dry ſolids, they then would become ſtrong electrics? M. *Boyle*, found by evaporating about a fourth part of good turpentine, that the remaining body, when cold, hardened into a tranſparent gum, almoſt like amber, which proved electrical: and by mixing two ſuch liquors as *petroleum*, and a ſtrong ſpirit of nitre, and then, diſtilling them, he obtained a brittle ſubſtance, as black as jet, which alſo was an electric. He likewiſe found that a glaſs made of the aſhes of antimony, and alſo a glaſs made of lead without any addition, had the ſame electrical properties with other glaſs. The glaſs of lead, he obſerves, might eaſily be brought again to afford malleable lead, which is a non-electric body. See his *Mechanical Production of Electricity.*

BY boiling turpentine and water together, which are two non-electrics, an hard tranſparent ſubſtance is produced called Colophony. This will move light bodies like amber upon friction; but if it be reduced into a fluid ſtate again by melting, then it becomes a ſtrong non-electric: as appears from its conducting the electric matter to other bodies, in like manner as iron, lead, or any other metal.

PROPOSITION XXXI.

SUCH ſolid bodies as are exceedingly elaſtic, and whoſe ſurfaces are ſmooth, regard being always had to the light which enters their compoſition, act more ſtrongly and uniformly upon the electric matter, as well as upon light, in refracting and reflecting it, than bodies that have thoſe properties in a leſs degree, and whoſe ſurfaces are not ſo even.

FOR a diamond, which is a body highly elaſtic, is alſo highly electric, and it reflects and refracts light more copiouſly than any other body. Glaſs is not ſo hard as a diamond, it is therefore probable, that it is leſs elaſtic; and we are certain that it is not ſo highly electric: nor does it reflect and refract light ſo copiouſly as a diamond.

WAX, though a body of a different nature from vitreous bodies, yet agrees with thoſe bodies in being an electric, and repelling the electric matter. It is not ſo ſtrong an electric as glaſs, though its refractive power exceeds the refractive power of glaſs conſiderably; one reaſon of which may be its want of hardneſs. For glaſs, as well as wax, when brought into a liquid, or ſoft form, become non-electrics: and as they cool and recover a ſolid form, they become again electrics. See propoſition xxix. Another cauſe of the difference between electrical bodies in their effects, may be the different ſmoothneſs of their ſurfaces, for the ſurface of a diamond is much ſmoother than the ſurface of glaſs; as may be gathered from its reflecting and refracting light more copiouſly, becauſe the rougher any ſubſtance is, the leſs regularly will light be reflected from it. If this be true, with reſpect to light, why may it not in ſome degree hold true with reſpect to electric matter?

From the ſame principles we may explain the difference between a diamond and amber: for was amber equally hard with a diamond, it is probable it would be a much ſtronger electric than a diamond; as its refractive power, in proportion to its denſity, is ſuperior to the refractive power of a diamond, in proportion to its denſity.

PROPOSITION XXXII.

Electric matter may be accumulated in electric bodies.

For, when a diamond is rubbed in the dark, it appears luminous, and attracts and repels light bodies, and theſe effects continue for ſome time after the rubbing ceaſes, which could not be the caſe, if electric matter was not accumulated within it[a]. How the electric matter is accumulated within the diamond, may be underſtood from propoſition xvi. For by friction the *atmoſphærula* of the diamond, and of the rubber, which are in contact with each other, are both rarified, whence the electric matter flowing from the rubber, muſt paſs with eaſe from it into the diamond. But the *atmoſphærula* on the other ſide of the diamond not being rarified, at leaſt to that degree, the electric matter cannot paſs out of the diamond ſo eaſily as it paſſes into the diamond: and therefore may be accumulated.

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[a] Let a large diamond be cemented to the end of a cylinder of glaſs, or wax, eight or ten inches long, and upon a cake of wax let there be placed a cuſhion which is made of hair and ſilk. If a perſon takes that end of the cylinder of glaſs in his hand, which is fartheſt from the diamond, and rubs the diamond upon the cuſhion, the diamond will not appear ſo luminous, neither will it act ſo ſtrongly upon light bodies, as when it is rubbed upon a non-electric.

THE effect, with reſpect to the electric matter's acting upon light bodies, is much the ſame, if, inſtead of a diamond, amber be made uſe of after the like manner; and it is probable, was amber equally tranſparent with a diamond, it would appear equally luminous.

THE ſame effects are obſerved, though in a leſſer degree, upon rubbing glaſs. The reaſon why theſe effects are not ſo ſtrong, ſeems to be, that the *atmoſphærula* of glaſs is not ſtrong enough to confine it within the body, but ſuffers it to paſs out more freely than the diamond.

THAT the accumulation of electric matter in bodies electrified ariſes from the reſiſtance being leſs where the electric matter enters than where it paſſes out, may be farther illuſtrated from what follows.

EXPERIMENT.

IF the glaſs G (fig. 1.) be exhauſted of air, and afterwards rubbed with a hand or cuſhion, the inſide of the glaſs will appear luminous.

THE reaſoning made uſe of in the xvith and laſt propoſitions, ſeems to hold equally true here; for the reſiſtance on the outſide of the glaſs, which ariſes both from its *atmoſphærula* and the ſurrounding air, being greater than on the other ſide of the glaſs, when the air is taken away, the electric matter ſhould paſs where the reſiſtance is leaſt, and this appears to be the caſe in the exhauſted glaſs.

IF it be ſuppoſed otherwiſe, to wit, that the electric matter accumulated between the pores of the glaſs, paſſes out into the air, ſurrounding the outſide thereof as readily, or nearly ſo, as into the exhauſted cavity; in ſuch caſe the reſiſtance given to its exit out of the glaſs ariſing from the *atmoſphærulæ* of the air and glaſs, ought not to be greater than in the other caſe. But this ſeems to be otherwiſe; for the accumulated electric matter in the pores of the glaſs, paſſing from thence into the exhauſted cavity of the glaſs, is oppoſed by the *atmoſphærula* of the glaſs only: whereas the outſide is oppoſed by the *atmoſphærula* of air as well as glaſs; and air, we have ſhewn, actually retards or oppoſes the paſſage of electric matter, as well as the *atmoſphærula*. Therefore ſuch a ſuppoſition cannot be true.

THIS ſeems to be farther manifeſted from the following experiment. For, if during the rubbing of the exhauſted glaſs, light bodies be brought near it, ſuch as pieces of leaf gold, down, feathers, &c. they will not be acted upon, and moved towards the glaſs ſo ſtrongly, as they otherwiſe would, was the glaſs not exhauſted.

QUERY. Whether this luminous appearance on the inſide of the exhauſted glaſs is not moſt viſible when the air therein is rarified to a certain degree?

PROPOSITION XXXIII.

When a non-electric body, which is not electrified, is made to approach ſo near to one electrified, that the force ariſing from the elaſticity of the electric matter within the body is greater, in that particular part of the body (by its endeavouring to paſs into the body which is not electrified) than the force ariſing from the elaſticity of its *atmoſphærula*, it will paſs off with a ſudden motion, and be condenſed more and more as it approaches the electric body; till at length an exploſion follows.

For as ſoon as the elaſtic force ariſing from the accumulated electric matter is ſufficient to overcome the elaſtic force ariſing from the *atmoſphærula*, by which the electric matter is retained in the body, and the leaſt quantity thereof moves towards the approaching body, the force with which it tends to the latter, increaſes every inſtant, and cauſes a greater condenſed focus of that electric matter, whilſt the force ariſing from the *atmoſphærula* decreaſes; conſequently the electric matter muſt paſs off ſuddenly, and not by degrees: and after coming into the air between the bodies, cauſe an exploſion by virtue of a ſulphureous matter that is carried along with it. See corrol. ii. prop. xvii.

SECTION XIII.

PROPOSITION XXXIV.

THE electric matter paſſes both into and out of bodies which have points, edges, or angular terminations, more readily than it does into, and out of bodies of the ſame kind which have no points, edges, or angular terminations.

THE truth of this is manifeſt from ſeveral experiments following the viith and xxii^{d} propoſitions.

PROBLEM.

LIGHT bodies moved to a body electrified, may be detained there by appoſing fine points or edges to them at a conſiderable diſtance: and if blunted or obtuſe points or edges of the ſame kind be appoſed at the ſame diſtance, thoſe light bodies will be no longer detained, but will recede from the electrified body. And upon appoſing fine points or edges again, the light bodies will be forced back again to the electrified body.

EXPERIMENT I.

[a] AT a foot diſtance (or thereabouts) from the bar B B (fig. 22.) hold a feather, or a piece

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[a] Mr. *John Canton* made ſeveral curious experiments of the ſame kind with this.

of down D, and when it leaves the hand, or is moving towards the bar, appoſe the point of a needle, which is not electrified, at fifteen inches, or a greater diſtance from the bar; but ſo that the down D may be between the bar B B and the point of the needle P. The down D, in this caſe, will be driven quicker and cloſer to the bar B B than if the needle was not appoſed: and the down may be detained there for any time by continuing to hold the needle in the ſame poſition; notwithſtanding the electric matter moves from the bar B B to the needle P. See obſerv. v. prop. 7.

EXPERIMENT II.

HOLDING the needle at the ſame diſtance as before, turn it, ſo that the eye or head thereof may point towards the bar B B, and the down D, and immediately on doing this the down will be no longer detained at the bar, but will recede or drop from it.

EXPERIMENT III.

TAKE two downy feathers, as nearly equal in ſize and weight as can be had, and place them at ſuch a diſtance from the bar B B, as that the electric matter iſſuing from the bar ſhall be able to move them towards the bar; and let one of thoſe feathers be ſeparated from the other two feet at leaſt. Then when the feathers begin to move towards the bar, let the point of a fine needle be appoſed to either of them; immediately on doing this, the feather, to which the needle is appoſed, will be driven to the bar, and detained there: whilſt the other, inſtead of approaching the bar, will recede or fall down, and remain unmoved, while the needle is held in the ſame poſition.

N. B. In theſe three laſt experiments, we ſuppoſe the wheel to be continued turning all the time.

To explain theſe phænomena from the principles we have been endeavouring to eſtabliſh:

Suppose an elaſtic medium to be diffuſſed through any given ſpace, and a cone BBP (fig. 22.) to be formed therein by the motion of particles of the ſame kind propagated from the ſurface of a body BB (ſituated in a part of that ſpace) in ſuch a manner as afterwards to tend to a point P. The action of a fluid thus moving and conſtituting the cone, will cauſe the elaſticity of the particles ſurrounding it to become greater, conſequently the fluid will be denſer on the outſide of the cone than in any part of the cone itſelf. And it will be rarer at the center of the baſe of the cone than in any other part of the cone; and in receding from the baſe to the vertex, its denſity continually increaſes. A light body then placed in the cone, cannot paſs out of it into the circumambient condenſed fluid, but muſt be forced cloſe to the center of its baſe; notwithſtanding the motion of the fluid is contrary, to wit, from the baſe to the vertex. Now, why may not the *æther* be the elaſtic medium diffuſed in the manner ſuppoſed above, and the needle's point be conſidered as the vertex of ſuch a cone whoſe baſe lies at the electrified body B B. The electric matter then will be denſeſt at the point of the needle P, leſs denſe between the needle's point and the bar B B, and rarer ſtill at the bar B B, conſequently the down D, or any other ſuch light body, when placed between B B and P, muſt be forced to the electrified bar B B; detained there, and preſſed in a manner cloſe to it, ſo long as the needle is held in the ſame poſition, and the body is continued to be electrified.

Hence may be ſeen the reaſon why both the feathers mentioned in the third experiment do not exhibit the ſame phænomenon.

If an obtuſe or broader pointed body (which muſt now be looked on as the ſection of a cone) be appoſed, as in the ſecond experiment, as the ſurface is hereby increaſed, the area of the *atmoſphærula* will be larger likewiſe; and the reſiſtance ariſing from it will be greater (ſee prop. ii.) therefore the electric matter will not tend towards it with ſo great a force as in the other caſe, becauſe it cannot diſſipate ſo faſt by this obtuſe point; but muſt paſs off in other places where the reſiſtance is leſs, by propoſition vii. and xvi. Now as all action between bodies is mutual and equal, and only a ſmall quantity of electric matter paſſes towards the obtuſe point, the force ariſing from this ſmall quantity muſt be weak and inſignificant; and the force with which the down will be repelled from it to the electrified body will be ſo too: nor can it poſſibly, as in the other caſe, be forced back towards the electrified body (unleſs the obtuſe point be moved nearer it) for the repelling force ariſing from the electric matter in this caſe will be greater between the feather and the electrified body, than between the feather and the obtuſe point.

WHAT has been ſaid already in regard to pointed bodies, we think, may be ſufficient for explaining the various phænomena producible therefrom: we ſhall only mention two or three experiments more of this kind, which are equally ſurpriſing, and leave the application of them to the reader.

EXPERIMENT.

IF a very fine downy feather F (fig. 23.) with long fibres, be fixed upon the bar B B, and electrified, the fibres will be ſtretched out in many directions, all of them receding from one another. Now if a perſon ſtands on the floor at the diſtance of two or three feet (nay ſometimes more, when the machine electrifies ſtrongly) holding a needle N, finely pointed, with the point towards the feather F, the fibres thereof will be forced cloſe together (as if they were preſſed) but always moſt on that ſide which is neareſt the needle. If the perſon, inſtead of ſtanding on the ground, ſtands upon wax, the effects will be weakened greatly.

EXPERIMENT.

AGAIN, if the perſon ſtanding either on the floor or on wax, turn the needle, ſo that the head thereof may point towards the feather, the fibres will then recover nearly their firſt form, or poſition, and be ſtretched out again in many directions, without any other change of circumſtances. But if the head of the needle be brought conſiderably nearer the feather, then the ſame phænomenon will inſue as happens from the fine points, though in a weaker degree.

EXPERIMENT.

IF a down feather, of the ſame kind with that made uſe of in the laſt experiment, have a thread four or five inches long faſtened to it, ſo that the thread may hang from the feather as many inches, the feather will be moved to the bar, and be ſuſpended; where it will continue whilſt the bar is continued to be electrified. But if a perſon who is electrified with a pair of ſciſſars in his hand clips the thread off, the feather will immediately fall, or be repelled from the bar.

SECTION XIV.

PROPOSITION XXXV.

LIGHT bodies, ſuch as down, leaf gold, leaf ſilver, &c. which in the open air are moved or forced to bodies electrified, will not be affected in like manner in *vacuo*, nor when the air is confined: provided the veſſel in which the light bodies and the electrified body are put, be ſet upon an electric body.

EXPERIMENT.

SUPPOSE C (fig. 24.) to repreſent a glaſs cylinder, to both ends of which A and B [a] are cloſely cemented two plates of metal. On the plate B is ſcrewed a ſtop-cock. Set this cylinder, having firſt exhauſted the air, and dried the glaſs very well upon wax w, ſtanding upon the end A, there being firſt ſome very light body laid within the cylinder at the bottom A, and the in and out ſide of the cylinder being well dried; then let a perſon ſtanding upon an electric, take hold of the moveable wire M, which is ſo contrived as to be puſhed up or down, as occaſion may require, without admitting the air. In ſuch circumſtances, the perſon and wire being both electrified, the leaf gold will not be raiſed from A, even though the wire M be moved extremely near to it. Nor does letting in the air ſeem to make any kind of difference.

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[a] *N. B.* The plates A and B ſhould be cemented to the glaſs, and not laid on with wet leather, unleſs it be with oil; but even that muſt be uſed ſparingly, becauſe the moiſture may adhere to the ſides of the glaſs, and thereby prevent the experiment ſucceeding.

N. B. We have not been able to find that cylinders of different lengths, or different diameters, produce different effects from what was obſerved in the laſt experiment. For upon making uſe of a cylinder two inches wide and forty inches long; and another of ten inches wide and fifteen deep, the leaf gold placed at one end, would remain there, though the electrified wire M was moved very near to it in each experiment.

PROPOSITION XXXVI.

Light bodies, ſuch as down, leaf gold, leaf ſilver, &c. when placed in a glaſs veſſel which ſtands upon a non-electric, will be differently affected by an electrified body, placed likewiſe in the ſame veſſel in air and in *vacuo*. In air, they will be moved towards the electrified body, and in *vacuo* they will not.

EXPERIMENT I.

INTO a cylinder of glaſs, eighteen inches long and eight inches in diameter, I put a little leaf gold; and afterwards cemented a plate of metal to each end of the cylinder: one of thoſe plates had a ſtop-cock fitted to it; and in another part of the ſame plate there was a collar of leathers, through which was put a wire of a conſiderable length. But before the plates were cemented, I hung a ſmall ball of metal to that end of the wire which was within the cylinder. Then ſetting that end, at which the leaf gold was laid, upon the ground; after having exhauſted the glaſs, I electrified the other end, by letting a chain, which hung to the bar, communicate with the braſs at the upper end of the glaſs; whilſt at the ſame time I ſtood upon wax, and held in my hand the end of the wire which paſſed through the collar of leathers. Upon moving the ball nearer to, or farther from the leaf gold, as I thought proper, I did not find in any of the trials that the leaf gold ever left the bottom plate: though I was convinced in every trial, from the exploſions which were cauſed ſometimes from myſelf, and at others from the wire, by the approach of a non-electric body, which was not electrified, as well as from other effects, that there was more than a ſufficient quantity of electric matter in the electrified ball to move the leaf gold.

EXPERIMENT II.

HAVING an opportunity of trying the laſt experiment with a glaſs of a larger ſize, and of the ſhape repreſented by the 25th figure, it being about fourteen inches deep, and about twelve inches wide in the broadeſt part, I repeated the experiment; but, inſtead of cementing the metal plates, I moiſtened a leather for each plate with a little oil, and inſtead of removing the glaſs from the air-pump, as was done in the laſt experiment, I continued it upon the pump, and cauſed a chain which was fixed to the bar to communicate with the wire and ball in the glaſs. Upon turning the wheel, and obſerving the degree of ſtrength of the electrifying power in the wire, I found the experiment to ſucceed in the ſame manner as was mentioned in the laſt experiment.

EXPERIMENT III.

UPON letting in part of the air, the leaf gold immediately moved from the bottom towards the electrified ball, but not ſo vigorouſly as when the whole air was let in: but even in this caſe the motion of the light body towards the elecfied body, did not appear altogether ſo vigorous as in the open air.

The reaſon why the leaf gold was not moved in the firſt and ſecond experiments, ſeems to be that the ſides of the glaſs were more ſtrongly electrified when the air was taken away, than when it was not; for when the ſides of the glaſs are electrified, they may diſturb the force which would otherwiſe cauſe the leaf gold to move towards the electrified ball, and that diſturbance muſt be greater or leſs, as the ſides of the glaſs are more or leſs electrified. For equal and contrary forces always deſtroy one another.

This reaſoning ſeems to be in a great meaſure confirmed from the different effects produced by glaſſes of different diameters.

EXPERIMENT IV.

For upon making uſe of a tube of glaſs eighteen inches in length and two in diameter, and another of four feet in length and two inches in diameter, I found that the leaf gold remained at reſt when the air was taken away; and that on letting in part of the air, or indeed the whole quantity, no apparent alteration was made; for the leaf gold continued unmoved in all theſe caſes.

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EXPERIMENT V.

UPON making uſe of a cylinder three feet in length and four inches in diameter, the other circumſtances being the ſame, I did not find any difference in the experiment, whether the air was exhauſted or not, excepting a very weak trembling motion of the leaf gold, which was obſerved in both caſes.

EXPERIMENT VI.

ON trying the ſame experiments with a cylinder of glaſs eighteen inches long, and five inches wide: the leaf gold appeared to be affected very near alike, whether the air was taken away or not. For when the air was taken away, the leaf gold ſeemed to ſhew the like trembling motion as mentioned in the fifth experiment; and when the air was let in, that motion ſeemed not much increaſed: but the leaf gold never left the bottom of the cylinder in either of theſe caſes.

IN theſe laſt experiments, when the ſeveral cylinders were exhauſted, I tried whether their outſides were electrified; and if they were, whether letting the air into the cylinders made any difference. I found that their outſides were electrified, and more highly ſo when the air was taken out of the cylinders than when it was not.

I LIKEWISE tried whether an exploſion could be produced in *vacuo* with the ſame ſucceſs as in air; and found that when the air was taken away, there was no exploſion.

PROPOSITION XXXVII.

A LIGHT body may be ſuſpended between two bodies, the one electrified, the other not, in ſuch a manner, as that it ſhall not touch either of them: and ſhall always be farther from the electrified body than the body which is not electrified, whether they be inverted or not. And the diſtance from the electrified body will be always greater or leſs, as the two bodies are more or leſs electrified.

EXPERIMENT I.

IF leaf gold, leaf ſilver, or any other light body, G (fig. 26.) be held near a plain of metal P, which is electrified, it will be moved towards the plane; and when G becomes equally electrified, it will recede from P (ſee experim. vii. ſect. iii.) But if another plane of metal P, which is not to be electrified, be held parallel to P, at about ſix or eight inches diſtance, ſo that G may be between them (nay, ſometimes at a much greater diſtance) the light body G will be ſuſpended between the two planes P and p. And if P and G are electrified to a great degree, the diſtance of G from P may be made greater than when they are electrified to a leſs degree.

EXPERIMENT II.

If a perſon ſtanding on wax, holds the plane p in his hand, the diſtance at which G will be ſuſpended from P, decreaſes as the perſon becomes more and more electrified: this appears from the perſon's being obliged to move the plane p nearer P, in order to keep the body G ſuſpended. But when the perſon and the plane p becomes equally electrified with P and G, then G will not be ſuſpended, but remain at reſt.

In order to explain theſe experiments, let us ſuppoſe the electric matter in a body, as it ruſhes out on the *æther* ſurrounding it, to form a kind of atmoſphere, which is of greater or leſſer extent as the body is more or leſs electrified (ſee experim. vii. ſect. iii.) When therefore two bodies are electrified to a great degree, the diameters of their atmoſpheres (if they may be ſo called) and the reſiſtance ariſing from them will be greater, than when they are electrified to a ſmall degree, and conſequently the greater will be the force with which they recede from each other. Now, if two bodies of unequal weights, ſuppoſe P and G, be equally electrified, and a third, which is not electrified, ſuppoſe p, be appoſed, as in the firſt experiment;

In ſuch circumſtances we find that G will be ſuſpended. And it will be nearer the non-electrified body p than the electrified body P; becauſe the reſiſtance ariſing from the *atmoſphærula* of p, is leſs than the reſiſtance ariſing from the electric atmoſphere of P. And this is farther confirmed from obſerving that upon electrifying p equally with P, as in the ſecond experiment, G continues no longer ſuſpended, but falls down by the force of gravity, the forces ariſing from the electric atmoſpheres of P and p, being now equal, and deſtroying each other.

Note, If G be very light, it may be ſuſpended without the aſſiſtance of the plane p, provided ſome other non-electric body be within four or five feet of the plane P, towards which non-electric G will always tend. The reaſon we have given before, ſeems to hold equally true in this caſe; for as the air may be electrified, and G tends towards the non-electric, the reſiſtance ariſing from the *atmoſphærula* of the air and the non-electric muſt be leſs than the reſiſtance ariſing from the electric atmoſphere of P. This is likewiſe confirmed from obſerving, that upon removing the non-electric to a much greater diſtance, G no longer continues ſuſpended.

EXPERIMENT.

IF two, three, four, or more pieces of leaf gold, leaf ſilver, or any other light bodies, be placed between the two planes P and p, as in the firſt experiment, when P is electrified they will be ſuſpended between the planes, but at a conſiderable diſtance from each other. For the atmoſphere of electric matter ſurrounding each piece, repels its neighbour, and prevents them coming together, or approaching nearer to one another, though their ſeveral diſtances from p, are nearly equal.

N. B. IN the making of this experiment, when the turning of the wheel, or the ſupply of electric matter is not equal, ſometimes two or more pieces of leaf gold will approach one another, and endeavour to form one continued line or ſtream of non-electric matter from P to p, by which means the electric matter will flow more readily from P to p; and oftentimes at that inſtant, moſt, if not all, of the other ſuſpended bodies drop down and remain at reſt.

WE have proved, that under certain circumſtances, thin electric bodies reſiſt or oppoſe the entrance of electric matter leſs than bodies of the ſame kind that are thicker.

WE have likewiſe ſhewn, that upon heating electric bodies they are rendered non-electric.

QUERY. May not theſe different effects obſerved between thick and thin electrics of the ſame kind; for inſtance, thick and thin cakes of wax, ariſe principally from the different quantities of light contained within different quantities of the ſame matter?

AND may not the different effects obſerved in electric bodies, when moiſtened, heated, or made fluid, from what are obſerved in the ſame bodies not affected by moiſture or heat, ariſe from ſome change in the *atmoſphærulæ* of the bodies, or in the texture of the parts of the bodies themſelves?

PROPOSITION XXXVIII.

IF a given quantity of electric matter was to paſs directly through any number of bodies of the ſame kind, placed in a right line of a given length, ſo that their diameters may meaſure the whole length of the line, the reſiſtance given to its paſſing through them will be leaſt when their diameters are the greateſt, and greateſt when their diameters are the leaſt; or in other words, the reſiſtance will be leaſt when it paſſes through the leaſt number, and greateſt when it paſſes through the greateſt number, both meaſuring the ſame length.

FOR if the reſiſtance given to the exit or entrance of the electric matter in non-electric bodies, ariſes only from the *atmoſphærulæ* ſurrounding them: and if the reſiſtance is the ſame in bodies of the ſame kind, whether they are large or ſmall: it is evident the leſser number of bodies the electric matter paſſes through, the leſser alſo muſt be the number of *atmoſphærulæ*, and conſequently the leſser the reſiſtance. But we have ſhewn that in bodies of the ſame kind, whether they are large or ſmall, the reſiſtance ariſing from their *atmoſphærulæ* is the ſame.

To illuſtrate this, let A, L (fig. 27.) repreſent the line given, B, C, two ſpheres, and a, d, a, v, the *atmoſphærulæ* ſurrounding them. If now a particle of matter be ſuppoſed to paſs along A L through B and C, it muſt paſs through four *atmoſphærulæ* only, to wit, a, d, a, v; whereas there would be many more for it to paſs through were there a greater number of bodies of ſmaller diameters placed in the ſame line[a].

Now the larger the body is, which a given quantity of electric matter is to be expanded in, the more that quantity will be rarified (ſee experim. ix. ſect. iii.) and the more it is rarified the leſs it will oppoſe the entrance of a freſh ſupply of electric matter. Hence we may gather the reaſon, why the electric matter in a body may have a ſtronger tendency to paſs into groſs bodies, ſuch as gold, ſilver, lead, iron, braſs, copper, tin, and all other metallic bodies, moiſt and fluid ſubſtances, and more particularly into the earth itſelf, than into dry air.

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[a] Since the refractive power of air is continually the ſame in all parts where the denſity is given; and as electrical experiments are for the moſt part made in ſpaces where the denſity of the air differs very little, the force which reſiſts the entrance of the electric matter into the particles may be ſuppoſed equal in the ſeveral particles.

THAT air reſiſts the paſſage of the electric matter will be farther illuſtrated from the following experiments.

EXPERIMENT I.

To each end of a hollow cylinder of glaſs G, about eighteen inches long (fig. 28.) and about five inches diameter, let there be fixed with cement two plates of metal B and C: through a hole in one end, ſuppoſe B, in which there is a collar of leathers, a wire w is to paſs, which may be moved higher or lower at pleaſure, in like manner as was directed in the experiment following the xxxivth propoſition. Let there be likewiſe on the outſide of one of the ends a ſtop-cock to ſcrew on to an air-pump, in order to extract the air out of the cylinder. In ſuch circumſtances either end of the cylinder may be electrified. Now upon electrifying either end (the room being dark) when the air is not exhauſted, no light will be ſeen to paſs from the wire w to the oppoſite end of the cylinder C, or from C to the wire w; whereas, if the air is exhauſted, and B is electrified, then a ſtream of light appears to paſs between the wire w and the oppoſite end C, repreſenting a cone, whoſe apex is at the end of the wire w at D, and the baſe at C.

EXPERIMENT II.

LET one end of a thin tube of glaſs (fig. 29.) two or three feet in length, and two or three inches in diameter, be hermetically ſealed, for example, at A; and to the other end B, let there be fixed a ſtop-cock, and let a ſtraight wire B C, ſix or eight inches long, be fixed to B, ſo that it may lie in the axis of the tube. Now, if the tube exhauſted of air, be ſuſpended with ſilk lines, and afterwards electrified, upon holding a non-electric body at the end A, a light will iſſue, which will ſeem to paſs from the wire towards A, even though the diſtance be more than two feet, and the *atmoſphærulæ* of the outer and inner ſurface of the glaſs are interpoſed between the wire and the non-electric body without.

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SECTION XV.

HITHERTO we have been endeavouring to eſtabliſh certain principles from experiments and obſervations. And though all of them may not be ſtrictly true, yet we hope that moſt of them may aſſiſt others in their inquiries after truth. What follows is an application of thoſe principles towards explaining the cauſe of gravitation, and ſome other phænomena. I am ſenſible that many may eſteem this an extravagant undertaking: but as every attempt to promote uſeful knowledge is truly laudable; and what I have delivered is propoſed only as queries; I hope it will meet with that indulgence and candour, which are the inſeparable attendants of diſtinguiſhed ſenſe and learning.

PROPOSITION XXXIX.

SINCE gravitation is ſuppoſed to depend upon the graduation of the denſity of the *æther*, it follows, that the more that denſity is increaſed, the greater will be the force of gravitation.

IF the *æther* be diffuſed, as Sir *Iſaac Newton* ſuppoſes, this propoſition is ſelf-evident.

PROPO-

PROPOSITION XL.

If *æther* be accumulated within a body, and the *æther* ſurrounding that body be equally denſe, and afterwards paſſes out from all parts of the body equally, the denſity, and conſequently the preſſure of the ſurrounding *æther* will be increaſed; and this increaſe of denſity will be greater or leſs, as the quantity paſſing out is greater or leſs: and will continue ſo long as the *æther* continues to paſs out of the body.

If we are able to accumulate the *æther*, then this propoſition is alſo ſelf-evident.

PROPOSITION XLI.

If *æther* be accumulated within a body, and the denſity of the ſurrounding *æther* be greater on one ſide of the body than it is on the other, the accumulated *æther* will paſs out in the greateſt quantity where the denſity of the ſurrounding *æther* is leaſt, and in the ſmalleſt quantity where the denſity of the ſurrounding *æther* is greateſt: or in other words, the accumulated *æther* will paſs out in the greateſt quantity where the reſiſtance is leaſt, and in the ſmalleſt quantity where the reſiſtance is greateſt: conſequently if the *vis inertiæ* of the body be leſs than the difference of the preſſure of the *æther*, or than the reſiſtance on any two ſides of the body in any inſtant, it will be moved towards that ſide, and in that direction where the preſſure upon the body, or the reſiſtance is leaſt.

For, if pieces of leaf gold, ſand, powdered glaſs, roſin, or any other light bodies, A, whether non-electrics or electrics, are electrified, and placed near a large non-electric body B, which is not electrified, they will move towards it with great rapidity. And if any other body, which is ſomething larger, be electrified and ſuſpended in a ſtring, ſo that it may hang in the ſame horizontal line with the non-electric, which is not to be electrified, the ſuſpended body will move from its natural point of reſt, and tend towards the non-electric body, which is not electrified. The reſiſtance on the ſide of A, next B muſt be greater than the reſiſtance on the ſide of A, which is fartheſt from B, from the *æther's* being rarer between bodies than without them. But the expanſive force in the accumulated *æther* within A is equal in every part, therefore A muſt move towards B.

PROPOSITION XLII.

If when *æther* is accumulated within a body B, part of it be ſuppoſed to paſs from it into another body A, in which the *æther* is not accumulated; the body A will begin to move when the difference of the preſſure of the *æther* on any two of its oppoſite ſides becomes greater than its *vis inertiæ:* and it will move towards that ſide where the preſſure, or the reſiſtance is leaſt.

EXPERIMENT.

LET a bar of iron repreſent the body B, and be electrified, upon bringing near to the bar pieces of leaf gold, ſand, powdered glaſs, roſin, or any other light bodies, whether non-electrics, or electrics which are not electrified, they will move towards the bar with great rapidity. And if any other non-electric body, which is not electrified, be ſuſpended in a thread, ſo that it may hang in the ſame horizontal line with the electrified bar, it will move from its natural point of reſt, and tend towards the electrified bar.

FOR B, in this caſe, from its *vis inertiæ* being greater than the difference of the preſſure of the *æther* on its two oppoſite ſides, cannot move towards A. But the accumulated *æther* in B can paſs into A, as there is no accumulation of *æther* in A, and may be there accumulated: and the greater the accumulation is, the greater will be the reſiſtance. This accumulated *æther* in paſſing from A into the *æther* ſurrounding it, muſt cauſe a greater denſity or preſſure upon the remote ſide of the body. A, for example, at x (fig. 30.) than on the nearer ſide into which the *æther* paſſes from B. And from this increaſed preſſure, A muſt of neceſſity approach towards B.

If the *æther* continues to paſs from B into A, and does not paſs out again ſo readily, the accumulated *æther* in A will at length become equal to the accumulated *æther* in B: becauſe A will receive continually the *æther* from B, till the expanſive force of the accumulated *æther* in A becomes equal to the expanſive force of the accumulated *æther* in B. And when that happens, both bodies muſt be equally electrified.

PROPOSITION XLIII.

When the *æther* is denſer between bodies than without them, ſo that the difference of the denſity exceeds the *vis inertiæ* of the bodies, they will recede from one another.

Now, when two bodies, ſuppoſe thoſe mentioned in the third ſection, experiment vii. are equally electrified, the *æther* muſt be denſer between them than on their outſides. For the *æther* cannot paſs from A into B, or from B into A, whilſt the bodies continue equally electrified. And it appears from experiment, that the *æther* does paſs out at their remote ſides, which it could not do if the *æther* was not rarer, conſequently the reſiſtance is leſs on the outſide of the bodies than between them; therefore if the *vis inertiæ* of either, or both, be leſs than the difference of the denſity of the *æther*, they muſt of neceſſity recede from one another.

The truth of the preceding propoſitions contained in this ſection, may be confirmed by a great variety of experiments. But as they are all pretty nearly of the ſame kind with thoſe already mentioned, and as they all ſeem to be explicable by the ſame principles, I ſhall only ſet down a few of the moſt material ones.

EXPERIMENT I.

Suppose A and B (fig. 31.) to be ſmall equal balls of cork or metal, ſuſpended in lines of ſilk, fifteen or twenty inches long, and hung at about ſix or eight inches apart. If one of them, for example, A be electrified, they will both move towards each other, and when the denſity of the electric matter in one, becomes equal to the denſity of the electric matter in the other, they will recede from each other.

EXPERIMENT II.

If the ſame balls be ſuſpended with thread inſtead of ſilk, and one of them, for example A, be ſuſpended on a non-electric body which is electrified; whilſt the other body B is ſuſpended on a non-electric, which is not to be electrified;

they will move towards, but never recede from each other, whilſt any conſiderable quantity of electric matter remains.

THE difference obſerved between this and the laſt experiment, is owing to the line and the body to which B is ſuſpended, which in this caſe are conductors of the electric matter. For the electric matter paſſing into B, is conveyed by the thread into other non-electrics, and as faſt as B receives it from A: ſo that there can be but very little if any difference between the denſity on the inſide and on the outſide of the bodies.

EXPERIMENT III.

IF the electric body A be ſuſpended with thread, and the other body with ſilk, then B will move towards A, and A towards B: and when B becomes equally electrified with A, both will be repelled.

THIS laſt experiment is the ſame in the effect with the firſt, only that the electrified body is ſuſpended with thread inſtead of ſilk.

EXPERIMENT IV.

IF A be ſuſpended by a ſilk line upon the bar, and be electrified by means of a wire, which is to be removed as ſoon as A is electrified: and B be ſuſpended by a thread line on a non-electric body, which is not to be electrified, they will move towards each other. On their near approach, the greateſt part of the accumulated electric matter in A will be diſſipated, and in a very ſhort time both A and B will recover their natural points of reſt.

For A having at firſt but a ſmall quantity of accumulated electric matter, and when it loſes any part thereof, being incapable of receiving more from the bar on account of the interpoſition of the ſilk line, ſo much electric matter as enters B will immediately paſs by the thread into other non-electrics.

Experiment V.

If a large non-electric body be laid upon an electric, and afterwards be electrified, a light body B, placed near, will be firſt moved towards, and afterwards driven from it.

This laſt experiment is ſimilar to the firſt.

Experiment VI.

If A be not electrified, and the light body B placed near it be electrified, it will be moved towards A: and upon its very near approach to A, will ceaſe to be electrified.

According to the before-mentioned law of the *æther*, its denſity in any body (ſuppoſing the denſity of the *æther* in a body to be inverſely, as the denſity of that body) will be exhibited in the following table. As alſo the proportion of the pores to the ſolid parts in the ſame bodies.

THE theorem from which the proportions of the pores to the ſolid parts were got, is the theorem by which Doctor *Robinſon* compoſed a table of the ſame kind, publiſhed in his *Appendix* to his *Diſſertation on the æther*.

$\frac{41.244-\Delta}{\Delta}$ the meaſure of the pores to the ſolid parts was thus found. Let the pores to the ſolid parts, or the ſpace poſſeſſed by the pores of a body to the ſpace poſſeſſed by its ſolid parts, be as P. to 1. Then $P+1$ will expreſs the whole ſpace poſſeſſed by the body, or the magnitude of the body. The quantity of matter in the body is meaſured by its magnitude and denſity taken together, that is, 1 is as $P+1 \times \Delta = P\Delta \times \Delta$, whence Δ is as $\frac{1}{P+1}$. The ſpecific gravity of fine gold by the table is 19.64. The ſpecific gravity of water 1; and Sir *Iſaac Newton*, from ſome obſervations, thinks gold has more pores than ſolid parts. Doctor *Robinſon* ſuppoſes the pores to the ſolid parts to be as 11 to 10. or as 1.1 to 1. In gold, therefore, Δ is 19.64 and $\frac{1}{P+1}$ is $\frac{1}{2.1}$, and to find the pores to the parts in another body, uſe this analogy $19.64 : \frac{1}{2.1} :: \Delta : \frac{1}{P+1}$. Now $\frac{19.64}{P+1} = \frac{\Delta}{2.1}$ and $41.244 = P\Delta + \Delta$; and $P = \frac{41.244-\Delta}{\Delta}$, the quantity of the ſolid parts being 1.

	Specific denſity of bodies, according to Mr. *Boyle* and others.	Denſity of the *æther*.	Pores to the ſolid parts
Fine gold	19.640	0.0509	1.100
Standard gold	18.888	0.0529	1.118
Quickſilver	14.000	0.0714	1.946
Lead	11.325	0.0883	2.641
Fine ſilver	11.091	0.0901	2.718
Standard ſilver	10.535	0.0949	2.916
Biſmuth	9.700	0.1031	3.252
Copper	9.000	0.1111	3.582
Caſt braſs	8.500	0.1176	3.852
Steel	7.852	0.1273	4.252
Iron	7.643	0.1308	4.396
Tin	7.320	0.1366	4.634
Glaſs of antimony	5.280	0.1893	6.807
A pſeudo-topaz	4.270	0.2342	8.659
A diamond	3.400	0.2941	11.130
Mr. *Ellicott* found the mean ſp. grav. of four Brazil diamonds ſeparately; two of them rough coats, and two bright coats to be	3.513	0.2846	10.741
And ten Eaſt-India diamonds of different colours to be	3.519	0.2841	10.720
The mean of both	3.517	0.2843	10.727
Clear cryſtal glaſs	3.150	0.3174	12.093
Iſland cryſtal	2.720	0.3676	14.163
Fine marble	2.700	0.3703	14.275
Rock cryſtal	2.650	0.3773	14.563
Common green glaſs	2.620	0.3816	14.742
Stone of mean gravity	2.500	0.4000	15.496
Sal. gem	2.143	04.666	18.246
Brick	2.000	0.5000	19.622

Nitre

	Specific denſity of bodies, according to Mr. *Boyle* and others.	Denſity of the *æther*.	Pores to the ſolid parts.
Nitre	1.900	0.5263	20.707
Alabaſter	1.875	0.5339	20.996
Dry ivory	1.825	0.5478	21.599
Brimſtone	1.800	0.5555	21.913
Dantzick vitriol	1.715	0.5831	23.049
Alum	1.714	0.5834	23.050
Borax	1.714	0.5834	23.050
Calculus humanus	1.700	0.5882	23.261
Oil of vitriol	1.700	0.5882	23.261
Oil of tartar	1.550	0.6451	25.609
Bezoar	1.500	0.6666	26.496
Honey	1.450	0.6896	27.444
Gum arabic	1.375	0.7272	28.995
Spirit of Nitre	1.315	0.7604	30.364
Aquafortis	1.300	0.7692	30.726
Serum of human blood	1.190	0.8403	33.658
Pitch	1.150	0.8695	34.864
Spirit of ſalt	1.130	0.8849	35.499
Spirit of Urine	1.120	0.8928	35.825
Human blood	1.040	0.9615	38.657
Amber	1.040	0.9615	38.657
Milk	1.030	0.9708	39.042
Urine	1.030	0.9708	39.042
Dry box-wood	1.030	0.9708	39.042
Sea Water	1.030	0.9708	39.042
Common water { freezing point = 0 boiling point = 100 $\frac{17 \text{ to } 18}{100}$ warm }	1.000	1.0000	40.244
Camphire	0.996	1.0041	40.409
Bees wax	0.955	1.0471	42.187
Linſeed oil	0.932	1.0729	43.257
Dry oak	0.925	1.0810	43.588

	Specific denſity of bodies, according to Mr. *Boyle* and others	Denſity of the *æther*.	Pores to the ſolid parts.
Oil olive	0.913	1.0953	44.176
Spirit of turpentine	0.874	1.1441	46.189
Rectified ſp. of wine	0.866	1.1547	46.626
Dry aſh	0.800	1.2500	50.555
Dry maple	0.755	1.3245	53.628
Dry elm	0.600	1.6666	67.704
Dry Fir	0.550	1.8181	73.981
Cork	0.240	4.1666	170.850
Air	0.00125	800.0000	32994.200

IT appears by this table, that the denſity of *æther* in gold is .0509, in cork 4.1666, in air 800.0000; ſo that the denſity of *æther* in cork is above eighty times greater than in gold, and in air, above one hundred and ninety times greater than in cork; conſequently the denſity of *æther* in air is above 15700 times greater than in gold. Hence the denſity of *æther*, in all probability, is much greater in air, than it is in groſſer bodies when they are electrified: that is, when the electric matter is accumulated in them. Whence it ſeems, that in ſuch bodies the force ariſing from the increaſe of denſity is ſo very weak, as only to impel light bodies, and thoſe at very ſmall diſtances; which diſtances vary as the machine electrifies more or leſs ſtrongly.

Vision, according to Sir *Iſaac Newton*, is performed chiefly by the vibrations of the *æther*, excited in the bottom of the eye by the rays of light, and propagated through the ſolid, pellucid, and uniform capillamenta of the optic nerves into the place of ſenſation. The ſeveral ſorts of rays make vibrations of ſeveral bigneſſes, which, according to their bigneſſes, excite ſenſations of ſeveral colours; the moſt refrangible rays excite the ſhorteſt vibrations, for making a ſenſation of deep violet. The leaſt refrangible the largeſt for making a ſenſation of deep red. And the ſeveral intermediate ſorts of rays, vibrations of ſeveral intermediate bigneſſes to make ſenſations of the ſeveral intermediate colours.

Query. May not this account be farther illuſtrated from the preceding principles? as thus—

If the rays of light be bodies of different ſizes, the leaſt of which make violet and the biggeſt red[a]: then the largeſt rays ſtriking upon the *atmoſphærula* of the *retina* at the bottom of the eye, will act upon a greater portion of that *atmoſphærula*, than the rays of light that are ſmaller. But the more parts of the *atmoſphærula* are acted upon by a ray of light, the ſtronger muſt be the effect; or in other words, the greater muſt be the vibrations. Thus it is, the largeſt rays of light cauſe the ſenſation of red, which is the moſt vivid; and the ſmalleſt the ſenſation of violet, which is the moſt faint and languid of all colours.

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[a] Nothing more is requiſite for producing all the variety of colours and degrees of refrangibility, than that the rays of light be bodies of different ſizes, the leaſt of which may make violet the weakeſt and darkeſt of the colours, and be more eaſily diverted by refracting ſurfaces from the right courſe; and the reſt as they are bigger and bigger, may make the ſtronger and more lucid colours, blue, green, yellow and red, and be more and more difficultly diverted. *Newt.*

Query, As to elaſticity, are not all the *phænomena* thereof deducible from the preceding principles, whether bodies rebound or recede from one another by percuſſion, or when they are forcibly bent, from their own ſpring they recover their original form and figure? For a fluid, whoſe particles recede from one another, with a force reciprocally proportional to the diſtance of their centers, will have its denſity proportional to its compreſſion (*Newt. Princip. prop.* xxiii. *book* ii.) when the *æther* is condenſed, its elaſtic force will be increaſed in the ſame manner as we find in air, when compreſſed or condenſed. Therefore when the parts of a body are brought nearer each other by any force, ſuch as bending or the like, the *æther* within, and the *atmoſphærula* without the body, will be condenſed at the ſame time, and by virtue of the condenſation (ſuch force ceaſing to act) they will be again made to recede from one another, and recover their former figure.

QUERY, May not coheſion, which is cauſed by a much greater force than that of gravity, ariſe from the mutual action of the light, contained within bodies, and of the *atmoſphærulæ* ſurrounding them, the preſſure of which *atmoſphærulæ* alone may be ſufficient to make the particles, when very near or in contact, cohere with a great force, after the manner we have particularly deſcribed in pag. If this is the caſe, the force of coheſion then muſt be proportional to the *atmoſphærulæ* of the particles. Now the *atmoſphærulæ* ſeem to be nearly, as the denſity of the bodies (See Propoſitions xx and xxi.) therefore the forces with which the parts of bodies cohere, are nearly proportional to their denſities.

" HENCE the denſeſt particles cohere with " the greateſt force, and as they leſſen in den- " ſity, ſo they do in the ſtrength of their co- " heſion. This force is of the ſame nature " with that of fermentation, for the nature of " the particles principally concerned in cauſ- " ing both coheſion and fermentation, are of " the acid, unctuous, and ſulphuruous kind.

CONCLUSION.

THERE have been ſeveral hypotheſes formed, in order to explain the cauſe of electricity; ſome have ſuppoſed that the electric matter is lodged within bodies, and ſuch only as are reſinous and vitreous; that it lies there in a quieſcent ſtate, but ready to fly off as ſoon as friction has ſufficiently agitated the parts, and dilated the pores: and laſtly, that the quantity of electric matter contained in ſuch electric bodies, reſiſts and oppoſes the entrance of the like kind of matter when it is conducted to them from other bodies. Others are of opinion that the electric matter is ſupplied from the air, and that friction ſerves only to collect it: while a third ſet of gentlemen would have it to be the ſame with *Boerhaave's* elementary fire. Theſe different opinions ſeem neither to be grounded upon reaſon, nor ſupported by experiments.

THAT the firſt two opinions are erroneous, will admit of no diſpute; for was the electric matter produced by friction, electric bodies could never by heat become non-electrics, it being the property of heat to rarify all bodies, even the moſt denſe. Was it wholly ſupplied by the air, bodies would at all times be equally electrified, whether the machine ſtood on the earth, or was placed on electrics.

As to the laſt, I ſhall refer the favourers of that opinion to Doctor *Boerhaave's* treatiſe on fire; where they may be convinced, that the notions he entertained of that element, are very different from what is here advanced concerning electricity [a].

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[a] To ſhew that this elementary fire differs from this electric matter, I ſhall ſet down ſome experiments and obſervations, which were communicated to me by Mr. *Smeaton*, the gentleman whom I have had frequent occaſion to mention in this Treatiſe.

EXPERIMENT.

Upon heating the middle of a large bar of iron to a glowing heat, and then electrifying it, the electrical phænomena, to wit, the power of moving light bodies, and the exploſion appeared to be much the ſame from the parts which were heated, and thoſe which were cooler: ſo that the electric matter paſſed through the fire without any viſible alteration.

OBSERVATION I.

Now as the ſuppoſed elementary fire filled the middle part of the iron bar, and was in ſome meaſure fixed therein, there is great reaſon to believe it would have obſtructed the paſſage of a fluid of the ſame kind, abſorbed it, diſſipated it, rarefied it, rendered it more or leſs elaſtic, or at leaſt have made ſome alteration in it, becauſe we always find that two neighbouring vortices of electric matter have a viſible effect upon each other, ſo alſo, two magnets aſſiſt, or obſtruct each other according to the ſituation of their poles.

OBSERVATION II.

When a body is heated, the elementary fire is not in equilibrio in every part of that body; for a body may be very hot

BUT as it is unreaſonable to deſtroy the hypotheſes of others, without eſtabliſhing ſome principles in their ſtead; I have therefore endeavoured to ſhow, That by friction a very ſubtile elaſtic fluid is accumulated or collected — which is capable of being diffuſed through ſome bodies, and not through others — the former are diſtinguiſhed by the name of Non-electrics, the latter by Electrics — That this fluid may be accumulated more or leſs in non electric bodies — That when it is accumulated, it will expand and diſſipate itſelf, and in the diſſipation exhibit, various phænomena, according to the circumſtances attending the experiment — That the exploſion and the power of moving light bodies, is not as the quantity, but the denſity of this fluid — and that it is propagated along denſe bodies with an exceeding great velocity

in one part, and leſs hot in another at the ſame time: whereas every body which is electrified, appears to be equally electrified in every part, and that whether it is equally hot or not.

EXPERIMENT.

The flame of a candle may be electrified.

OBSERVATION.

This is a farther confirmation, that elementary fire may be electrified.

To this I ſhall add, that with reſpect to the exploſion, it may probably be owing to very volatile ſulphureous parts, thrown off from bodies by the violent motion of the electric matter, which volatile ſulphureous parts, mixing with the acid in the air, kindle into flame.

—That this fluid, when it is accumulated in a body, will paſs into thoſe bodies which are neareſt, and give the leaſt reſiſtance—That it is ſupplied from adjacent bodies and the earth itſelf—That the original quantity of this fluid in a non-electric body, may be leſſened or increaſed—That when bodies receive a greater quantity of this fluid, than originally belonged to them; non-electrics that are contiguous, and the earth itſelf, muſt loſe ſome part of the quantity of this fluid, which they originally had—That in certain circumſtances, neither the attenuation nor accumulation of this fluid in a body, can by any methods, hitherto known, be made to exceed a certain degree—That the accumulation of this fluid, in ſome circumſtances, is in the direct proportion, and in other circumſtances, in the reciprocal proportion to the reſiſtance it meets with, as it tends to diſſipate—That nearly the ſame effects are produced by the attenuation, as by the accumulation of this fluid—That upon an exploſion part of the accumulated fluid may be forced through mediums, which reſiſt differently, and that, by the reaction of the particles of the fluid—That on cauſing an exploſion with the vial, the whole quantity of accumulated electric matter that is diſſipated, does not paſs off at that part of the body where the ex-

ploſion

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ploſion is made, but from all parts of the ſurface, even though it be covered with a thin electric—That the accumulated electric matter is not totally diſſipated by repeated exploſions—That when the electric matter is accumulated in the vial, the loudneſs of the exploſion, and quantity of electric matter diſſipated on compleating the circuit, ſeem proportional to the points of non-electric contact with the out, and in ſide of the vial—That when the electric matter is accumulated in the vial, the greateſt effects are produced by compleating the circuit. How it comes to paſs, that the greateſt part of the accumulated electric matter is diſſipated by one exploſion, I have not taken upon me abſolutely to determine; but in order to aſſiſt others, who may purſue theſe inquiries farther, I have ſet down ſeveral experiments of different kinds, and from them propoſed a query, concerning the manner in which it ſeems to be effected; and likewiſe, concerning the manner in which that painful ſhock or convulſion of the nerves and muſcles, which is generally felt by animals, may be cauſed—That this ſtrange effect ſeems proportional to the magnitude of the exploſion—That we cannot determine, from the appearance of the divergency of the electric matter which body it iſſues from; becauſe the electric matter both in paſſing out of a body, and paſſing into it, has the ſame appearance—That if a perſon compleats the circuit, the greateſt painful ſhock will be always felt in thoſe parts, which lie in the ſhorteſt line that can be drawn through the perſon, from the covering of the vial to the wire—That non-electric bodies, placed at ſmall diſtances without the circuit, will be affected in the ſame manner, but in a leſs degree, as if part of the electric matter had paſſed into them—That an exploſion never happens, but when the iſſuing electric matter is very much condenſed—That the greateſt exploſion is from poliſhed ſurfaces—That the exploſion is greater, the larger the ſurfaces are, to a limited degree, and—That denſe bodies, in their natural ſtate, are capable of receiving a greater quantity of electric matter, than bodies that are rare.

In the ſecond part, we have given a ſhort account of the *æther*, Sir *Iſaac Newton* has treated of; then compared it with the properties of the electric matter, and ſhewn, that they ſtrongly reſemble each other—We have therefore conſidered the electric matter as *æther*, joined with groſſer particles, propelled from bodies by the force and vigour of its action—That according to the law of the *æther*, when a body is made rarer, the *æther* in that body muſt grow denſer, and *vice verſa*—That friction will cauſe bodies to rarify, as well as the heat of the ſun or any other heat—and That thoſe rarified bodies will contract and grow denſer, on diſcontinuing the friction, or on removing their rarified parts from the friction—That as bodies grow rarer by heat, *æther* flows into them from other bodies—and as they grow denſer by cold, *æther* flows out of them into other bodies—That when two bodies are rubbed againſt each other, the *æther* will flow in a greater quantity into the rarified parts of the bodies, than into thoſe parts of the ſame bodies which are not rarified—And upon the parts of the bodies growing denſer, the *æther* muſt paſs out of theſe bodies, where it meets with the leaſt reſiſtance—That this flowing of the *æther*, which produces all the electrical effects, can only be cauſed by friction—That the flowing of the *æther* muſt gradually leſſen on diſcontinuing the friction—and that the electric effects from the glaſs muſt grow weaker, as it cools and recovers its original ſtate—That it is in ſome degree neceſſary for the cylinder to be turned always one way—That equal effects can never be produced in the bar from the cuſhion and glaſs, by the application of heat without friction—That two thick electrics, rubbed againſt each other, can never produce ſo ſtrong electrical effects, as when an electric and a non-electric are rubbed againſt each other —That ſetting the machine on non-electric bodies, moiſtening the leather of the cuſhion and all other circumſtances, to keep an open communication with the cuſhion, are abſolutely neceſſary for producing the greateſt flux of the *æther*—That in order to ſee how far the *æther* is capable of being accumulated in a non-electric body, it is abſolutely neceſſary to ſuſpend, or ſet the non-electric upon ſome electric, which obſtructs or reſiſts the entrance of the *æther*, more than non-electric bodies do —and that the electric bodies ſhould be always dry and free from dirt—That when the *æther* is put into ſuch a motion within a body, as is deſcribed in prop. xvi. it will throw off, by the violence of its action, ſulphur, and other matter lodged on the ſurface, or within the pores, where it is leſs intimately combined with, and united to the parts of, that body—That this ſulphurous matter, when it is thrown off in any conſiderable quantity, ferments with the nitrous acid floating in the air, which fermentation is probably the cauſe of the ſudden blaſt, or violent exploſion obſerved in ſome of the electrical experiments—That *æther* is more ſubtile than light—That denſe bodies have more light in their compoſition than bodies that are rare, unctuous and ſulphurous ones excepted—That unctuous and ſulphurous bodies have more light in their compoſition, than other bodies of the ſame denſity—That the power in bodies to refract, reflect, and inflect the rays of light, is nearly proportional to the quantity of light contained in them—That the inflective, refractive, or reflective power of a body extends itſelf but to a very ſmall diſtance from the body—That this power ſeems to be cauſed by the mutual action of the light in bodies, and the *æther* at their ſurfaces—That it is of a very great denſity, and extends to a very ſmall diſtance from the ſurface of a body—That the rays of light ſeem to be reflected regularly by virtue of this medium—That this medium, which we have called the refractive, reflective, or inflective medium, or, in one word, by *atmoſphærula*, prevents the electric matter, when accumulated within a body, from iſſuing ſo faſt as it otherwiſe would, if there was no *atmoſphærula* ſurrounding that body—That the electric matter, when it iſſues ſuddenly through a denſe *atmoſphærula*, produces a greater effect than when it iſſues through a rare one—That in two or more circuits made at the ſame time, with the ſame vial, but with different bodies, the electric matter will paſs only in that circuit, where there are the feweſt *atmoſphærulæ*; or, in other words, where the reſiſtance is leaſt—That this reſiſtance may be leſſened, as in the chain, by bringing the links into cloſer contact with each other—That the particles of air have probably *atmoſphærulæ* ſimilar to the ſame kind of bodies, which are groſſer and larger—That a ſufficient number of them, with ſuch *atmoſphærulæ* placed in a medium, ſuch as the *æther*, may conſtitute an elaſtic fluid, reſembling the atmoſphere of the earth—That if any non-electric matter be put into a glaſs, whoſe *atmoſphærula* is very great, and be afterwards electrified, the reſiſtance the electric matter will meet with in paſſing out on compleating the circuit, ſeems to be as the thickneſs of the glaſs, the quantity of non-electric contact with the glaſs, and the ſum of the ſeveral *atmoſphærulæ*; to wit, of the diſſipator, the glaſs veſſel, and the matter contained within it—That from the different denſity of the *atmoſphærulæ* ſurrounding bodies, it principally is, that ſome are electric, and others non-electric, regard being always had to the texture of the bodies; thoſe bodies which have the denſeſt *atmoſphærulæ*, ſuppoſing them not fluid, moiſt, or ſoft, are called electrics, and thoſe which have the rareſt *atmoſphærulæ*, non-electrics—That any fluid may be electrified, though the *atmoſphærulæ* of many fluids are much denſer than that of common glaſs—

—That electric bodies may be rendered non-electrics by heat, glaſs and amber not excepted—That hardneſs ſeems to be a neceſſary property for making bodies electric—That electric matter may be accumulated even in electric bodies—And that it will always paſs away where the reſiſtance to its exit or entrance is the leaſt—That the electric matter paſſes off with a ſudden motion, when its denſity in any particular part of a body exceeds the denſity of the *atmoſphærula*—That the electric matter paſſes both into, and out of bodies, which have points and edges, more readily, than it does into and out of bodies of the ſame kind, which have no points or edges; and from thoſe properties, we have endeavoured to explain ſeveral curious *phænomena*, in relation to pointed and edged bodies.

In the xiv Sect. we have ſhewn the effects of electric matter upon light bodies, in confined air, and *in vacuo*, as well as in the open air—That the difference between thick and thin electrics of the ſame kind, and the alteration made in their effects by heating, may ariſe from a change in their *atmoſphærulæ*, or in the texture of the parts of the bodies themſelves—That if a given quantity of electric matter paſſes directly through any number of bodies of the ſame kind, placed in a right line of a given length, the reſiſtance given to its paſſing through them will be leaſt, when it paſſes through the leaſt number, and greateſt when it paſſes through the greateſt number — That the larger the body is, which a given quantity of electric matter is expanded in, the more that quantity will be rarified, and the more it is rarified, the leſs the reſiſtance — From thence I gathered the reaſon, why the electric matter has a ſtronger tendency to paſs into groſs bodies; ſuch as metals, fluids, &c. and the earth itſelf, than into dry air.

IN Sect. xv. which is the laſt, I have endeavoured to explain the nature of the force, by which light bodies are moved in electrical experiments, and attempted to ſhew, that it is the ſame force with that which cauſes gravitation; which force can be no other, than a fluid exceedingly more ſubtile and elaſtic, than air, at the ſurface of the earth.

WHAT I have ſaid on theſe matters, is intended chiefly as hints, to excite others to make further reſearches. That many and uſeful diſcoveries will, one day or other, reſult from the doctrine here advanced, how crude and indigeſted ſoever it may now ſeem, no doubt, I think, is to be made. Abler hands may extend theſe inquiries farther, and probably complete what I have begun. I ſhould not be ſurprized, if the nature of muſcular motion, vegetation, and even magnetiſm itſelf, ſhould be hereafter explained upon the ſame principles.

However this may be, what I have advanced ſeems to have the advantage of the ſeveral hypotheſes hitherto framed for explaining the nature of electricity, as it is the moſt univerſal and conſiſtent with itſelf; at the ſame time, that in the moſt plain and ſimple manner it accounts for the other phænomena in nature, as well as thoſe in electricity.

If the exiſtence of an *æther* be admitted, we may reaſon by analogy concerning other parts of this planetary ſyſtem. Heat is obſerved to decreaſe in receding from the ſun, and this decreaſe is demonſtrated, to be as the ſquares of their diſtances. Was our earth then removed three times farther than it is from that luminary, the effects of heat would be nine times leſs; was it placed three times nearer, it would be nine times greater than in our preſent ſituation; in the former caſe, our water would freeze and become ſolid; in the latter it would be even hotter than boiling water, and be more eaſily evaporated. If therefore there are any fluids in the reſt of the planets, which are in our ſyſtem, their parts muſt be exceedingly rare in thoſe fartheſt from, and exceeding

ceeding denſe in thoſe which are neareſt to the ſun; for otherwiſe they could never be preſerved in a ſtate of fluidity by degrees of heat, which are ſo very different [a].

LASTLY, as matter is in itſelf inert, the *æther* muſt of neceſſity receive its activity from an *infinitely wiſe*, and *powerful ſpirit*. This *æther*, from its being ſo general a material cauſe, may probably be the great inſtrument, by which the Almighty directs, governs, and ſupports the univerſe.

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[a] Prop. viii. Theorema viii. Cor. 4. *Newt*, Princip. Denſiores igitur ſunt planetæ qui ſunt minores, cæteris paribus, ſic enim vis gravitatis in eorum ſuperficiebus ad æqualitatem magis accedit. Sed & denſiores ſunt planetæ, cæteris paribus, qui ſunt Soli propiores; ut Jupiter Saturno, & Terra Jove. In diverſis utique diſtantiis a ſole collocandi erant planetæ ut quilibet pro gradu denſitatis calore Solis majore vel minore frueretur. Aqua noſtra, ſi Terra locaretur in orbe Saturni, rigeſcerit, ſi in orbe Mercurii in vapores ſtatim abiret. Nam lux Solis, cui calor proportionalis eſt, ſeptulo denſior eſt in orbe Mercurii quam apud nos: & thermometro expertus ſum quod ſeptulo Solis æſtivi calore aqua ebullit. Dubium vero non eſt quin materia Mercurii ad calorem accommodetur; & propterea denſior ſit hac noſtra; cum materia omnis denſior ad operationes naturales obeundas majorem calorem requirat.

EXPERIMENTS
UPON
HUMAN BODIES.

IN the month of *May* 1748, I had an opportunity of trying the effects of electricity upon a woman in *London*, who had been deaf many years; ſhe was born in the iſland of *Nevis* in the *Weſt-Indies*, and was about 28 years of age. Her name is *Mary Smargins*.

SEVENTEEN years ago, ſhe became ſo deaf as not to hear any one, unleſs they were very near, and ſpoke loud to her. This deafneſs proceeded firſt, as ſhe believes, from a cold, and was never obſerved to be better at intervals. She always heard the leaſt with the left ear; and when at any time the right ear was laid upon a pillow, or ſtopped, ſhe could diſtinguiſh loud ſounds but very faintly.

I WAS the more induced to make a trial of the electrical effects in this caſe, not only from what I was informed had been done at *Paris*, in caſes of the like nature, but alſo from what Mrs. *Smargins* herſelf told me. That a few days before, upon her being electrified with other perſons in my apartments by the vial, ſhe felt a very unuſual warmth acroſs the ſtomach and in each arm, which continued for ſome time: that on the next day, ſhe had obſerved a running at her noſe, which ſhe attributed to her having been electrified, and which ſhe imagined was of ſome little ſervice to her. For theſe reaſons, and from an opinion, that the cauſe of this deafneſs might proceed from ſome obſtruction in the auditory nerves, which might probably be removed by the violent effects of this ſubtile electric matter; I propoſed to her, the giving the electrical ſhock, with the vial, acroſs her head.

On *Saturday* the 28th of *May*, I made the firſt experiment in the following manner.

The covered vial being electrified by two turns of the wheel only, I applied the end of a thick wire, which was faſtened to the covering of the vial, to the left temple, juſt above the ear; then I brought the end of that wire, which was in the vial, towards the oppoſite part of her head, and there enſued a ſmall exploſion. She was much ſurprized, and perceived a ſmall warmth in her head, but chiefly acroſs it, from ear to ear. I repeated the experiment four times, and made the electrical ſhock ſtronger each trial. The warmth excited by the ſhock increaſed in each experiment, and though I cauſed the experiment to be made at each ear alternately, ſhe always found the warmth to be greateſt in that ear ſhe heard the leaſt with. At laſt ſhe complained of ſmall twitchings in her ears and acroſs her head, but moſtly in that ear ſhe heard the leaſt with. When theſe experiments were made ſhe did not perceive that any other part of her body was affected by the ſhock. All this day the warmth increaſed, and at intervals ſhe felt twichings in her ears. Her hearing ſhe imagined was ſomething better, ſo did the people with whom ſhe lodged. She was adviſed to keep her head warm. I was informed that in the evening, ſhe waſhed her head in cold water. The next morning early, which was *Sunday*, I repeated the experiments again in the ſame manner, and nearly with the ſame ſtrength. At this time ſhe complained of her arms and body being affected by the ſhock, and ſaid that I had made it much ſtronger than the day before. The warmth ſeemed now quite round each ear, but ſtill greater round that with which ſhe heard the leaſt; the twitchings were alſo more violent. Theſe effects continued all the day. There were ſeveral ſigns this day of her hearing better. For in her lodgings ſhe heard the bells ring, which ſhe had never done before; and the gentlewoman with whom ſhe lodged, obſerved, that ſhe could underſtand what was ſaid to her, though ſpoken in a moderate tone of voice. After theſe experiments, notwithſtanding ſhe was adviſed to take particular care of catching cold, ſhe ſat at night in the window above an hour with the ſaſh open, and her cap pinned up. This evening the warmth left her, and was ſucceeded by a great coldneſs in her head, and a chillineſs all over her body.

THE next morning, which was *Monday*, ſhe was extremely ill, with pains all over her. I did not care to try any more experiments whilſt ſhe continued in this diſorder.

ON *Tueſday* ſhe was much better, the coldneſs abated, and ſhe felt again round each ear the ſame kind of warmth which ſhe had before obſerved. —This day ſhe mentioned ſeveral circumſtances, which ſhewed her hearing was better, particularly the following ones. She could diſtinguiſh the cries in the ſtreets, and the barking of dogs; and could hear people in the houſe with her going up and down ſtairs, though ſhe herſelf ſat in the uppermoſt room of the houſe.

ON *Wedneſday* ſhe was ſomething better in all reſpects, and the noiſe and continual beating in her head, which ſhe had had from the firſt of this misfortune, began now to abate conſiderably. In the evening a very violent ſhooting (as ſhe expreſſed it) went acroſs her head, from the left to the right ear. This day I did not repeat the experiments, but on the day following, which was *Thurſday,* I did. Some minutes after making them, ſhe had occaſion to blow her noſe, when there iſſued corrupted matter with a ſmall quantity of clotted blood. All this morning ſhe felt in her head a glowing warmth, greater than had ever been before. This day, as ſhe was reſting her head upon a pillow, ſhe heard the cries in the ſtreet, notwithſtanding that ear with which ſhe always heard the moſt, was cloſe to the pillow, and was ſo ſurprized and rejoiced, that ſhe got up immediately, to acquaint the gentlewoman of the houſe with it. At noon ſhe heard a perſon at the bottom of the ſtairs calling her down to dinner, though the door of the chamber in which ſhe ſat, was at that time ſhut. Several times that day, I ſpoke to her in a lower tone of voice, than is uſual in converſation, and ſhe gave me direct anſwers to the queſtions I aſked her. She ſaid the noiſe and beating in her head was then almoſt intirely gone.

THIS day ſhe could hear the opening and ſhutting of the ſtreet door. In the evening Dr. *Bevis* (whoſe name I have mentioned in the preceding Treatiſe) called upon me, as alſo did two other gentlemen, when I related to them this affair, and at the ſame time, deſired

they

the would ſtep with me to her, and aſk ſuch queſtions as they ſhould think proper. Upon my ſpeaking to her in a very moderate tone, to my great ſurprize, ſhe deſired I would not talk ſo loud: and what is very remarkable, ſhe had at this time cotton in both her ears, two caps pinned cloſe about them, and a velvet hood on, to keep her warm. As I was obliged to leave town the next morning, I told her, that in my abſence Dr. *Bevis* would be ſo kind to repeat the experiments, if ſhe thought it neceſſary — This ſhe declined, ſaying, that ſhe could not find there was any occaſion; for that ſhe heard very diſtinctly, and her head was very eaſy.

I FORGOT to mention one circumſtance, which was this; ſhe had a great cold, and her eyes were much inflamed at the time I began to make theſe experiments. The inflammation decreaſed after the firſt experiments on *Saturday*, and it was intirely removed after the ſecond experiments on *Sunday*. The diſappearing of which inflammation, ſhe ſolely attributed to the electrical effects. From that time to this, I have not been in *London*, but have had ſeveral letters from my friends, giving an account, that ſhe continues to hear very well.

I HAVE tried theſe experiments upon ſix other perſons, whoſe complaints were deafneſs, but without any ſucceſs. Three of them indeed fancied themſelves better for a few days. One of the others, inſtead of receiving any benefit, complained of a violent pain in his head, and a dimneſs in his eyes; which he ſaid continued for ten or twelve days after the experiments were made.

A GENTLEMAN near ſeventy years of age, was deſirous to feel the ſhock, occaſioned by approaching the vial. I was afraid of electrifying the vial too ſtrongly at the firſt trial; but upon his declaring he ſcarcely felt any pain, I electrified it much ſtronger the ſecond time, and afterwards as ſtrongly as I could; nevertheleſs he was not affected, as is uſual, in the arm and acroſs the breaſt, but only in his wriſts.

IN *Auguſt* 1748, I had occaſion to try ſome experiments, in order to obſerve the different effects produced by a perſon's compleating the circuit with the vial, in different manners; the experiments were of the ſame kind, with thoſe mentioned in the ixth propoſition. I made uſe of my own ſervant, who was about 25 years of age. After the firſt and ſecond experiments, he complained of his ſpirits being depreſſed, and of being a little ſick. Upon making the fourth experiment, he became very warm, and the veins of his hands and face ſwelled to a great degree. The pulſe beat more than ordinarily quick, and he complained of a violent oppreſſion at his heart (as he called it) which continued along with the other ſymptoms near four hours. Upon uncovering his breaſt, it appeared to be much inflamed. He ſaid that his head ached violently, and that he felt a pricking pain in his eyes and at his heart; and a pain in all his joints. When the veins began to ſwell, he complained of a ſenſation which he compared to that ariſing from ſtrangling, or a ſtock tying too tight about the neck. Six hours after the making of the experiments moſt of theſe complaints left him. The pain in his joints continued till the next day, at which time he complained of weakneſs, and was very apprehenſive of catching cold. On the third day he was quite recovered.

THE ſhocks he received were trifling compared with thoſe which are commonly received by moſt perſons when they join hands to compleat the circuit for amuſement. His being affected more than ordinary might be owing to his conſtitution; for he was conſumptive, and had been ſo for a long time before the making of theſe experiments.

WHEN the experiment with the vial was firſt made by *Muſchenbroeck*, ſoon after I diſcovered a method of increaſing its effects, and

was

was then able to indure the moſt violent ſhocks along my arms and acroſs the breaſt: but upon repeating thoſe ſhocks often for ſeveral weeks together, I at laſt was weakened ſo much that a very ſmall quantity of electric matter in the vial would ſhock me to a great degree, and cauſe an uncommon pain. So that I was obliged to deſiſt from trying any more. Whether it had any effect upon my health or not, I cannot ſay; but even to this day I am affected nearly in the ſame way by the electrical ſhock.

In order to ſhew how ſtrongly my arms were convulſed, after I had been weakened by frequent repetitions of theſe experiments, I ſhall mention one experiment which the following accident gave riſe to. I undeſignedly touched the wire in the vial when it was electrified at the time that I had a ſlender braſs wire in my hands, and the ſhock was ſo great that it broke the wire into two pieces and hurt both hands. I then thought of trying it with a thicker wire, and after a more ſecure manner: for this purpoſe I fixed a piece of leather round each wriſt, and faſtened a wire about the thickneſs of a very ſlender knitting-needle to each leather. I then with one hand took hold of the covering of the vial when it was ſtrongly electrified, and with the other I approached the wire in the vial: on doing this there iſſued a very violent ſhock or convulſion of the muſcles of my arms and body, and the wire which was faſtned to the two leathers was broke aſunder about three inches from the middle. The length of the wire from wriſt to wriſt was about fourteen inches.

UPON rubbing with my hand a glaſs globe which was turned round on its axis, I have at different times been affected with a very violent head-ach, which always went off upon diſcontinuing the rubbing of the globe, and quitting the room.

I HAVE met with many perſons who complained that they have found an unuſual pain to continue for ſome days after receiving the ſhock.

I HAVE been aſſured from ſeveral perſons who made the experiments, that the electrical ſhock has been of great ſervice in removing many diſorders, particularly fixed rheumatic pains; but I cannot ſay that it was of any remarkable ſervice in four or five caſes of the ſame kind where I tried it.

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Miſcellaneous Experiments.

Experiment I.

TWO pendulums of equal lengths ſuſpended on the ſame horizontal line, which was about ſeven feet from the floor of the room, were made both to vibrate at the ſame time. Upon electrifying one of them, I obſerved that the pendulum which was electrified vibrated quicker than the other which was not, and ſtill more ſo the nearer the ball of the pendulum was to a non-electric body which was not electrified.

Experiment II.

Having filled a veſſel with water, and immerged one end of a ſiphon therein, I ſet the veſſel upon wax and covered it with a glaſs receiver, the ſides of which were moiſtened with water to render it non-electric. I then electrified the receiver and ſiphon, and found that, while the ſiphon was covered with the receiver, the water did neither flow faſter out nor ſpread to a greater diſtance than it did when they were not electrified. But upon taking away the receiver, the water immediately ſpread to a conſiderable diſtance.

N. B. This

N. B. This laſt experiment may ſerve to ſhew that the motion of the blood is not increaſed by electrifying the animal. For the veſſel and ſiphon covered with the receiver may be looked upon in nearly the ſame light with the body of the animal, the fleſh and ſkin covering the veins and arteries as the glaſs receiver does the ſiphon; and in both caſes the ſurrounding bodies being non-electrics. When the glaſs is taken away, the water ſpreads, from the great tendency the electric matter in the water has to paſs into the adjacent non-electrics which are not electrified. And for the ſame reaſon, the blood, upon being electrified, will, when a veſſel is opened, ſpread to a greater diſtance.

EXPERIMENT III.

I have been able by ſtriking ſolid bodies together very briſkly, to produce a light reſembling that produced by the electric matter, nay, even by ſtriking my hands one againſt the other when they were very dry, I have produced a faint bluiſh light, which diſappeared almoſt the inſtant the ſtroke was over. But for this laſt experiment it is neceſſary that the room ſhould be very dark, and that the perſon ſhould be ſome time in the room before he trys it, that the pupil of his eyes may be ſufficiently dilated.

EXPERIMENT IV.

IF a tube of glaſs and a bar of iron be electrified, the one by friction and the other by the cylinder, to ſuch a degree as that each of them ſhall move a light body from the ſame diſtance; the glaſs tube will retain electric matter longer than the bar, as appears from the light bodies continuing to be moved for a longer time towards the tube than towards the bar.

THE glaſs tube, when electrified, muſt be either laid upon or ſuſpended by electrics.

EXPERIMENT V.

WHEN the bar is electrified, if a perſon ſtanding on the earth touches very lightly with one hand a non-electric, at the ſame time that his other hand approaches the electrified bar, he will not only feel a ſmart ſenſation in the hand next the bar, but alſo in the hand touching the non-electric. If one, two, three, or more perſons at the ſame time touch very lightly with their fingers different parts of this perſon, and one two, three, or more perſons at the ſame time touch lightly different parts of theſe perſons, and continue to do ſo when the firſt mentioned perſon approaches the bar; immediately on his cauſing the exploſion from the bar they will all feel a ſmart ſenſation, but none will feel it ſo ſtrong as the perſon who cauſes the exploſion. In this experiment all the perſons concerned are to ſtand upon the earth. See page 15, and propoſition xii.

EXPERIMENT VI.

I SET a glaſs tube open at both ends, which was about twenty-four inches long, and three inches wide, upon an air-pump; the uppermoſt end was covered with a plate of metal and leathers: a moveable wire about twenty inches long was put through this plate in a collar of leathers, and at the end of this wire within the tube was ſuſpended a braſs ball. Then after having exhauſted the tube and electrified the coated vial, the wire which paſſed into the vial was brought near to the moveable wire in the plate, at the ſame time that a chain communicated with the outſide covering of the vial and the top of the air-pump. On doing this, it ſeemed as if part of the electric matter which was accumulated in the vial, paſſed out of it and through the diſſipator; though the diſtance of the braſs ball from the bottom was about twelve inches. For the experiment being made in the dark, a light was ſeen to dart in rays from the ball towards the air-pump.

EXPERIMENT VII.

THIS laſt experiment was repeated, and a perſon made part of the circuit without receiving the convulſive ſhock.

Experiment VIII.

Upon lowering the ball no change appeared, except that the light within the glaſs ſeemed a little brighter.

Experiment IX.

When the ball was raiſed twenty or fifteen inches, there was no light within the glaſs.

Experiment X.

On letting in part of the air, and trying all theſe experiments over again, no light was ſeen in the glaſs, nor did it appear that any electric matter eſcaped out of the vial upon compleating the circuit in the manner we have now been mentioning. See page 84 and 85.

I DESIRED a friend of mine, who has made the new kind of air-pump which I have mentioned before, and to whom I owe the contrivance of the electric machine repreſented in the firſt figure, to try what would be the effects in an electrified glaſs when the air was exhauſted; and the account he has tranſmitted to me of the experiment is as follows.

A glass whoſe length was about one foot, and greateſt diameter eight inches, open at both ends, had one of its ends cloſed by a braſs ferril, which conſtituted one of the centers on which it turned; the other end was cloſed with a metal plate: in the center of this plate was a ſquare ſtem, which was applied to the arbor of a lath by which the glaſs was turned round. On one ſide of this laſt plate was fixed a cock, by means whereof the glaſs was ſcrewed upon the air-pump.

Upon rarifying the air within the glaſs about five hundred times, and afterwards turning the glaſs in the lath, whilſt at the ſame time it was rubbed with my hand, a conſiderable quantity of lambent flame, variegated with all the colours of the rainbow, appeared within the glaſs under the hand: this light was pretty ſteddy in every reſpect, except that every part of it was perpetually changing colour. When a little air was let into the glaſs, the light appeared more vivid and in a greater quantity, but was not ſo ſteddy, for it would frequently break out into a kind of corruſcations like lightning, and fly all about within the glaſs. When a little more air was let in, this flaſhing was continual, and ſtreams of bluiſh light ſeemed to iſſue from under my hand within the glaſs in a thouſand forms with great rapidity, and appeared like a caſcade of fire. Sometimes it ſeemed to ſhoot out into the forms of trees, moſs, &c. When more air was let in, the quantity of light was diminiſhed, and the ſtreams compoſing the flaſhes narrower. The glaſs now required a greater velocity and harder friction, Theſe circumſtances increaſed as more air was let in: ſo that by ſuch time as the glaſs was one third full of air, theſe corruſcations quite vaniſhed, and a much ſmaller quantity of light appeared partly within and partly without the glaſs. And when all the air was let in, the light appeared wholly without the glaſs, and much leſs in quantity than when the glaſs was in part exhauſted.

EXPERI-

EXPERIMENTS

UPON

Artificial Magnets.

MR. *Boſe*, profeſſor at *Wittemburgh*, in a letter to the Royal Society in *London*, gave an account that he had been able, by the effects of electric matter meerly, to invert the poles of natural magnets, deſtroy their virtue intirely, and give it again *de novo*: but did not take notice of the method he made uſe of for that purpoſe: nor have I yet heard of any one perſon who has ſucceeded in the making of theſe experiments.

As I did not think it impoſſible that ſome change might be made in the powers of magnets by the electric matter, I was induced to try ſeveral experiments of this ſort. And tho' I did not obſerve any remarkable change, I thought an account of the ſeveral experiments would not be unacceptable in this Treatiſe.

The magnets I uſed in the following experiments were made by Dr. *Knight*, each of them about eight inches long.

Experiment I.

Having obſerved the greateſt weight each of them could lift, which was nearly equal, I ſuſpended one of them by a thread fifteen inches long to the end of the bar B B, with the north pole uppermoſt, and cauſed the wheel to be turned twenty minutes. On taking it from the thread, I found that it raiſed the ſame weight it did before it was electrified.

Experiment II.

I then ſuſpended the ſame magnet again, but with the ſouth pole uppermoſt, and after it had been electrified for the ſame length of time, I removed it from the thread, and found that it raiſed the ſame weight.

Experiment III.

By holding the north end of one of the magnets near a braſs globe ſuſpended by the electrified bar, I cauſed ſeveral exploſions between the magnet and globe; and on taking it away, I did not find any alteration made in its power.

Experiment IV.

Upon repeating the experiment with the ſouth pole next the globe, no viſible alteration enſued.

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EXPERIMENT V.

I SET the vial with the filings, after they were ſtrongly electrified, upon wax, and then taking one of the magnetic bars in my hand, I made the north pole approach the wire in the vial at the ſame time that I touched a braſs wire faſtened to the outſide covering of the vial with the ſouth pole: ſo that in this caſe the magnetic bar was the diſſipator. And on doing this a large exploſion inſued, by which the greateſt part of the electric matter accumulated in the filings was diſſipated. I repeated the experiment ſeveral times, and could not find upon examining the power of the bar, that it had undergone any change, either with reſpect to its polar or magnetic virtue.

EXPERIMENT VI.

I REPEATED the ſame experiment an equal number of times, with the ſouth pole uppermoſt, and did not find any ſenſible change in the magnet.

EXPERIMENT VII.

I SUSPENDED the ſame bar again with the north pole uppermoſt, and then brought a thin plate of glaſs, which was laid on the palm of my hand, into contact with the ſouth pole of the magnet, and there continued holding it whilſt the wheel was continually turned for near thirty minutes. On my taking away the magnet, and trying its ſtrength, I found no variation, nor indeed any alteration in its poles.

EXPERIMENT VIII.

I REPEATED the experiment with the ſouth pole of the magnet uppermoſt, and the ſucceſs ſeemed to be the ſame.

EXPERIMENT IX.

AFTER ſuſpending the ſame bar again in thread to the electrified bar, I brought very fine filings of iron near it, and obſerved that the filings did not adhere to the bar ſo ſtrongly as when it was not electrified.

EXPERIMENT X.

INTO a vial filled with quickſilver and covered on the outſide with lead, I put one of the magnetic bars inſtead of the crooked wire w, the north pole of the magnet being without the neck of the vial. After electrifying the vial for a conſiderable time, I found that the magnet had neither loſt nor gained ſtrength.

EXPERIMENT XI.

UPON repeating the experiment with the ſouth pole, no alteration was obſerved.

EXPERIMENT XII.

I THEN put the ſame bar into the vial with the north pole out as before, and when the quickſilver and magnet were ſtrongly electrified, I brought the end of a diſſipator made of braſs near the bar, and cauſed an exploſion. I repeated this experiment about forty times, and, upon examining the power of the magnet, I perceived little or no alteration; the difference, if any, was a diminution of its virtue.

EXPERIMENT XIII.

I REPEATED the experiment with the other bar, the ſouth pole being without, and ſo far as I was able to obſerve, there did not appear to be any remarkable difference.

EXPERIMENT XIV.

THE vial and bar being electrified as in the former experiment, inſtead of making uſe of a piece of braſs to cauſe the exploſion, I uſed one of the magnets as a diſſipator, and placed the ſouth pole of one near to the north pole of the other, with a piece of braſs eight inches long between the poles, to prevent them acting upon one another. And to prevent the magnet which was without the vial from being affected by the bar within, and the iron wire ſurrounding the vial, there was another piece of braſs eight inches long in contact with the covering of the vial, and the other pole of the magnet. On electrifying the vial, and cauſing ſeveral exploſions, I found that both the magnetic bars retained nearly their former virtue.

The END.

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E R R A T A.

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	12.		26.		the experiment		the firſt experiment
	13.		12.				fig. 2.
	25.		15.		fig. 2		fig. 3.
	26.		24.				fig. 3.
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Fig. 1.

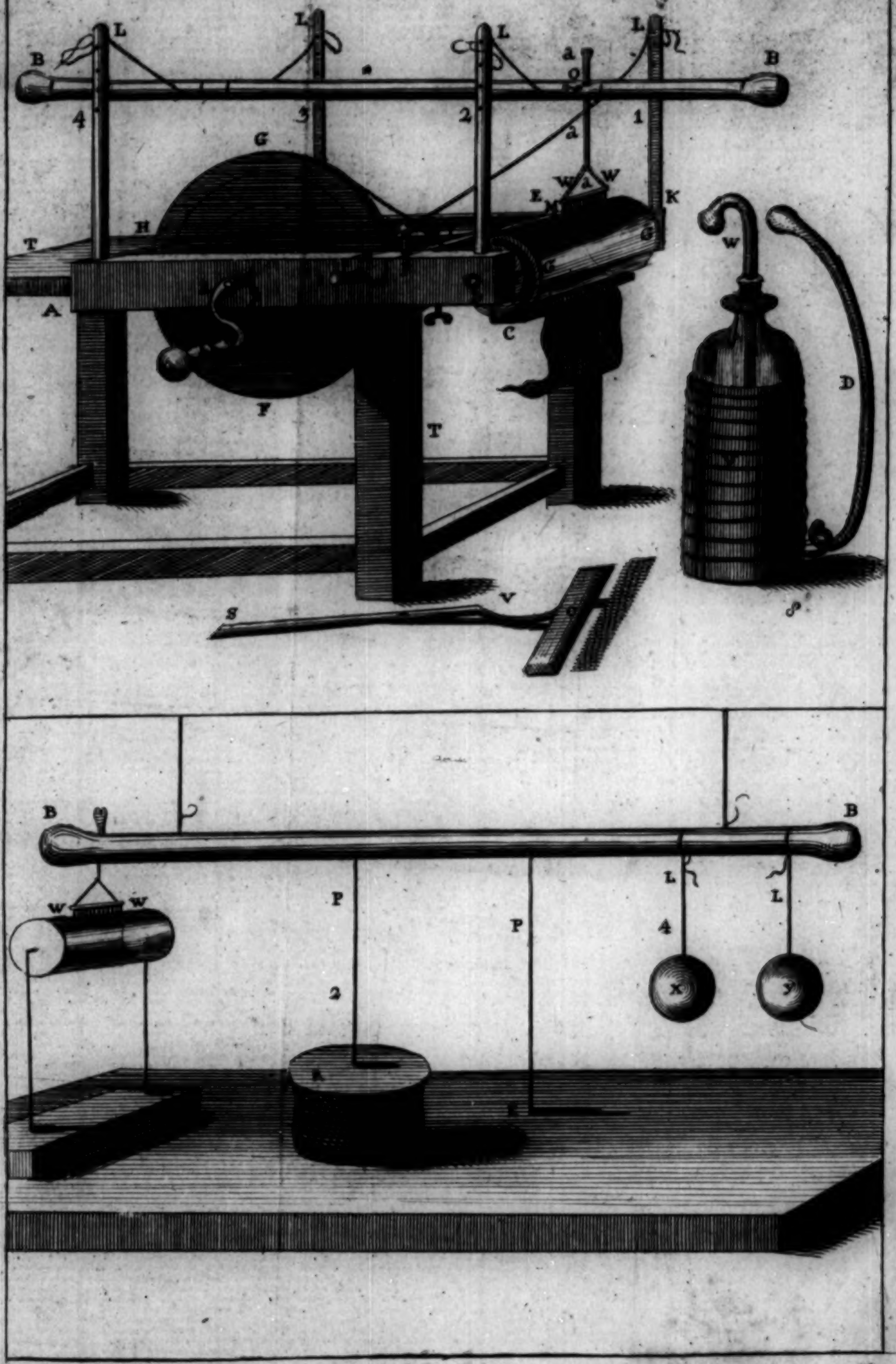

Fig. 3.

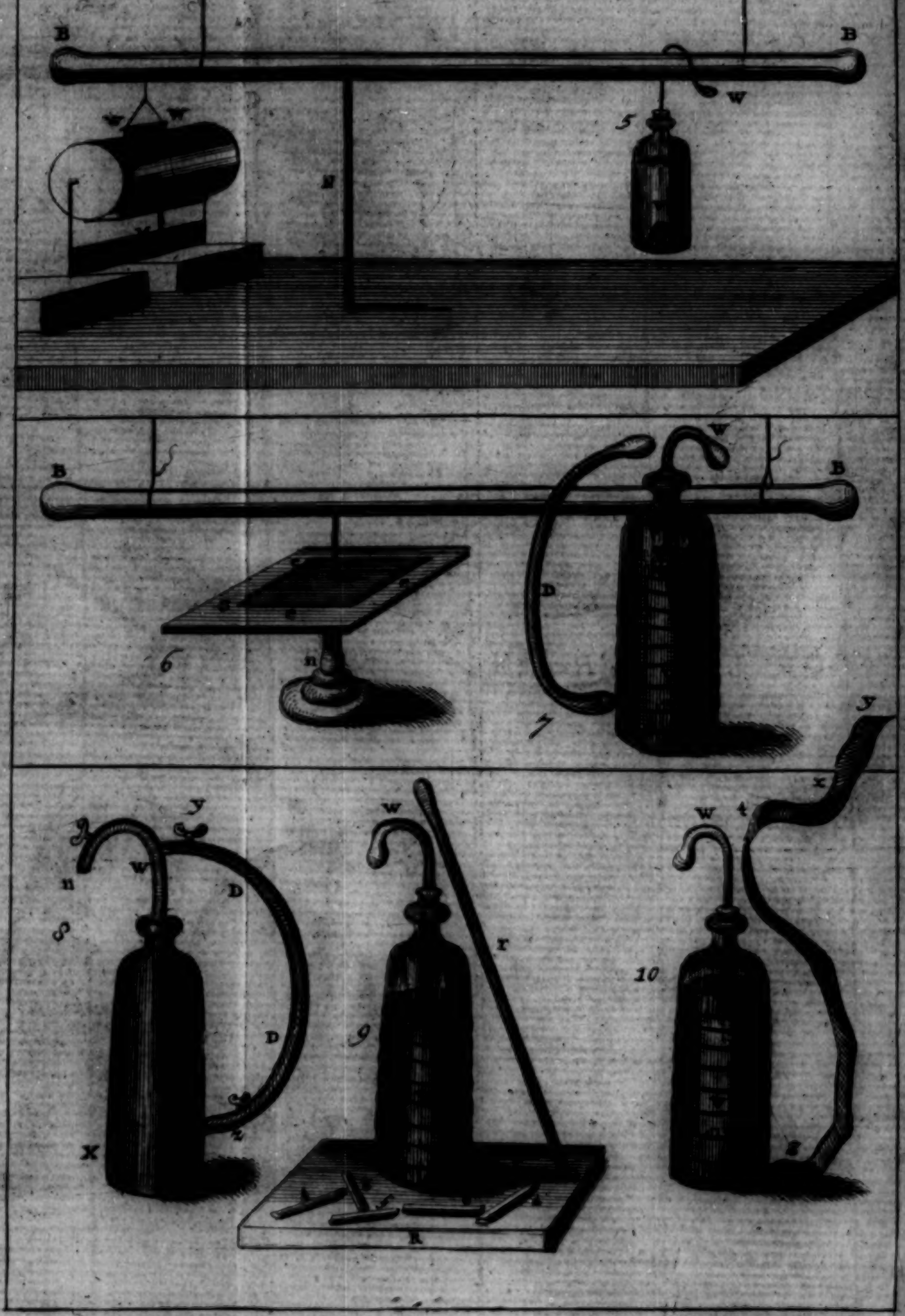

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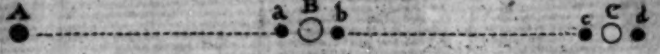
Fig. 12.



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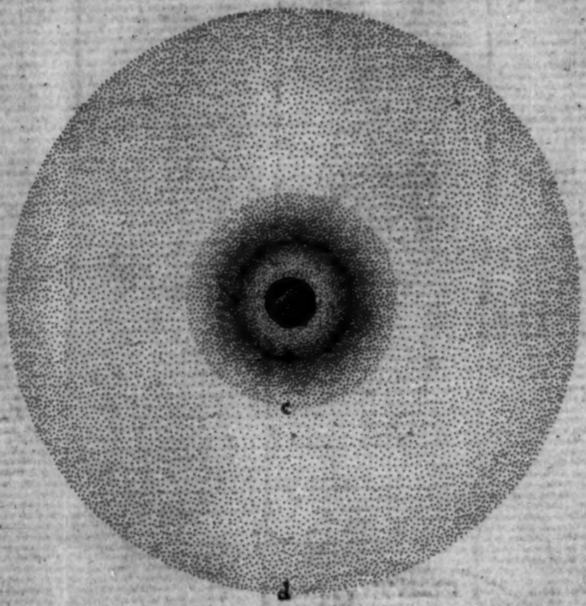

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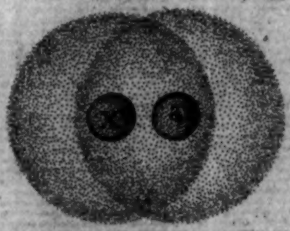

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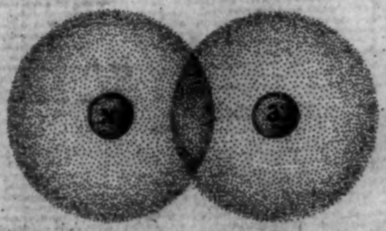

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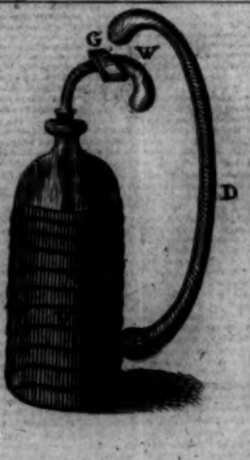

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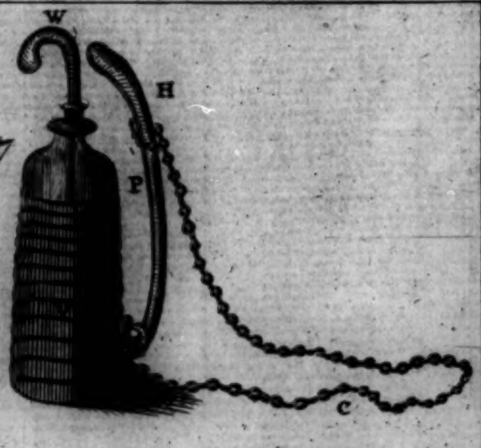
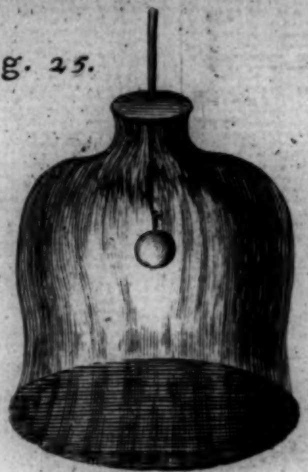


Fig. 25.



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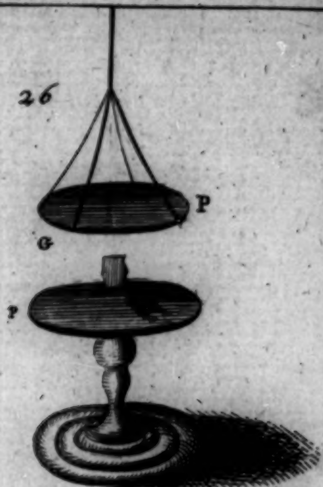

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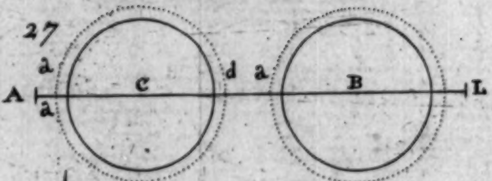

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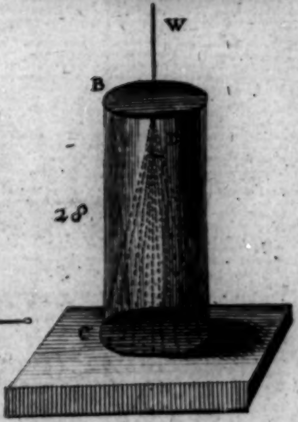

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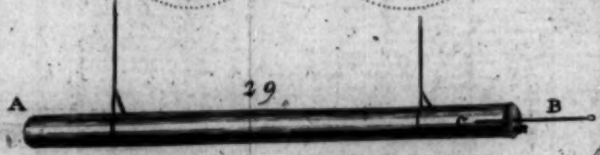

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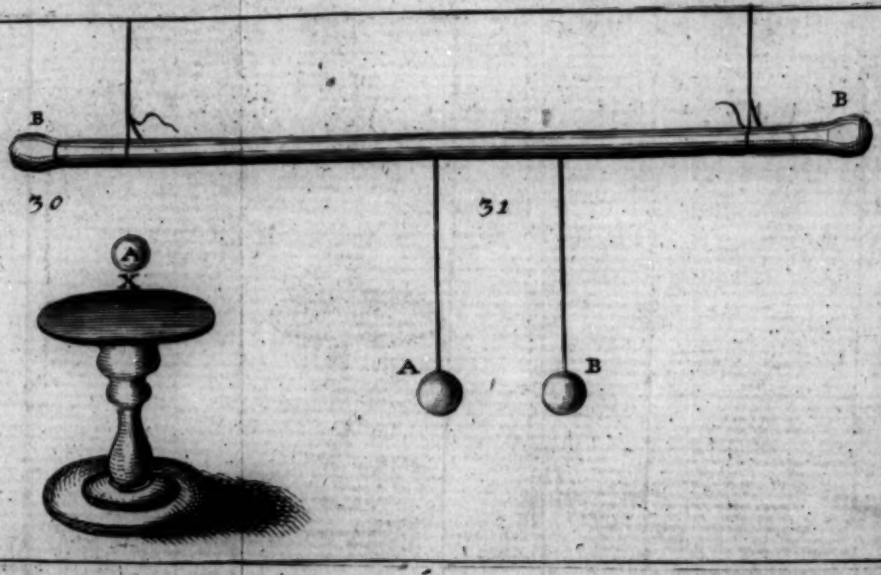

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